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HISTORY
OF THE
PROGRESS
AND
PRESENT STATE
OF
ANIMAL CHEMISTRY.

BY

W. B. JOHNSON, M.B.

IN THREE VOLUMES.

VOL. I.

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PREFACE.

IT was the precept of an eminent philoſopher, that he who undertakes to extend the limits of a ſcience ſhould previouſly be made acquainted with the diſcoveries of his predeceſſors. To facilitate the application of this precept, firſt induced the Author to make the following compilation.

That all organized bodies are compoſed of ultimate or remote parts, will not be denied, but there ſeems to be a prevalent idea, that it is neceſſary for theſe component parts to be in certain proportions or peculiar combinations, in order to eſtabliſh the equilibrium of health; and that when theſe are deſtroyed, diſeaſe is the conſequence, which cannot be cured until the organic machine receives thoſe parts which are deficient, or gives up thoſe which are in exceſs, ſo that the proper proportions be again effected, and the equilibrium of health reſtored. If ſuch be the caſe, the concluſion is, that the happineſs or miſery of individuals depends ultimately on the proportion of the different parts of the ſubſtances that compoſe them.

The human intellect appears to delight in ſpeculation; for the idea has been extended ſo far as to ſuppoſe, that ſince the mind is only the production of external objects acting on vital organization, conveyed by ſenſes, all of which are compoſed of ultimate parts; this nobler part of our nature muſt likewiſe be within the reach of the powers of the analytical ſcience, and that ſome diſtant and future age may be indebted for an explanation not only of the functions of the body, but of the faculties of the mind, to chemical analyſis.

At preſent, there are not a ſufficient number of facts to warrant a concluſion, that theſe ſpeculative opinions can ever be verified, although, from the diſcoveries chemiſtry has already made, and the vaſt extent of it's capacity for future inveſtigation, it perhaps would not be a juſt way of reaſoning to aſſert the impoſſibility: who could have believed, thirty years ago, that either fixed air or water was capable of decompoſition, that the diamond was nothing but charcoal, and that fleſh might be converted into ſpermaceti? Yet this ſcience is only in it's infancy, whilſt it's progreſs is deemed to be eternal.

Every attempt is laudable in the cauſe of humanity, although it ſhould be fruitleſs, and the chemical phyſiologiſt need not be informed of the great importance it would be to medical ſcience to bring theſe opinions to the teſt of experiment, to prove or refute them, and to aſcertain whether the deficit and ſurplus in the proportions of the remote parts of organic bodies are not rather to be numbered amongſt the *effects* than the *cauſes* of diſeaſes.

The phyſiologiſt who undertakes ſuch an inveſtigation, need not be diſcouraged at the quickſands of former times into which ſo many have fallen; he will find that the preſent ſtate of chemiſtry is different from what it was at that unfortunate period, when the extravagancies it introduced into medicine made the alliance dangerous. Modern chemiſtry has already thrown great light on ſeveral parts of the animal ſyſtem; it has within theſe laſt few years commenced an inveſtigation of ſeveral of the functions of the body, and explained the manner in which they are carried on with ſome degree of ſucceſs: the proceſſes of reſpiration, of perſpiration, of digeſtion, of animalization, and the action of oxygen upon vital organization, no longer remain in that ſtate of total darkneſs in which they were ſo lately enveloped, whilſt the proficiency already attained in this department of the ſcience, has eſtabliſhed the animal analyſis upon ſo firm and broad a baſis, as to promiſe in future the happieſt reſults. Other functions remain to be inveſtigated, ſuch as ſanguification, oſſification, nutrition, and the ſecretion of the different fluids; to which may be added the action of thoſe powers that produce diſeaſes, and that of medicines on the animal body; but it is by purſuing the ſame method of analytical reaſoning that their operations are to be explained, and their nature thoroughly underſtood. Every preparation is already made for this grand work, and there is reaſon to believe, that the route which has hitherto been explored will conduct the philoſopher to a more preciſe and exact knowledge of the phenomena of the animal economy, and to the formation of a more perfect theory of the laws that govern the vital and mental world.

What has been ſaid of the medical ſcience may be extended to the arts. Several of theſe, it is well known, are indebted to the animal kingdom for their reſpective materials; and the enlightened artiſt need not be informed of the great deſideratum of having the nature and properties of the materials he employs thoroughly inveſtigated by chemical analyſis; it is, perhaps, the only means by which his art can be reduced to ſcientific principles, by which his operations can be ſimplified, his proceſſes accelerated, and his labours ſhortened. It is to this ſcience that the arts of dyeing, tanning, making of glue, of hats, of cutlery, the operations of cookery, the proceſſes of the dairy, &c., have been brought to their preſent ſtate of perfection, and it is to the ſame ſource they can only look for future improvement.

For ſuch an undertaking, a material advantage, however, ſeemed to be wanting: a compilation in which the enterpriſing experimentaliſt could be made acquainted with the facts and obſervations of thoſe who had preceded him. It is true, ſeveral learned foreign chemiſts have attempted to ſupply this deficiency, and Gren, Hildebrandt, Jacquin, and de la Grange, have publiſhed compilations on the ſubject; but their plans appear to have been too limited, and their deſcriptions too conciſe; many of the phenomena recorded in the analyſis of animal ſubſtances have been excluded, ſome of the moſt intereſting particulars have been forgotten. In the work now preſented to the public, a different plan has been purſued, a more enlarged ſcale has been attempted, and an endeavour has been made to give the whole a more connected and ſyſtematic arrangement. For theſe purpoſes, the Author is principally indebted for his information to the Elementa Phyſiologiæ of Haller, the Encyclopédie Méthodique of Morveau and Fourcroy, and to Leonhardi's German tranſlation of Macquer's Chemical Dictionary, with the excellent additions. At the ſame time, copious extracts have been occaſionally ſelected from more recent publications, particularly thoſe collections of different learned ſocieties, to whoſe diligence and induſtry chemiſtry preſents her choiceſt ſtore. From the former, the early hiſtorical part has been chiefly taken; from the latter, the ſtate of analyſis of the preſent day. With ſuch aſſiſtance, it is to be hoped, the deficiencies of former compilers may have been in ſome meaſure ſupplied, and the knowledge they have collected increaſed, by having had acceſs to a more extenſive maſs of materials, and to later diſcoveries.

When this compilation was nearly finiſhed and ready for the preſs, appeared the *Syſtème des Connaiſſances Chimiques* of Fourcroy. This celebrated chemiſt, it appears, had anticipated the deſign of the preſent work, and from the extenſive range he has taken over this part of the ſcience of chemiſtry, from the vaſt addition of facts his publication includes when compared with preceding writers, and the great acceſſion of original matter with which he has enriched the ſubject, the Compiler would have been inclined to have deſiſted from the undertaking, had he been previouſly informed they were about to travel the ſame road. It is now too late to recede, and he delivers it to the public with all it's imperfections.

Derby, Dec. 1ſt, 1801.

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THE HISTORY OF ANIMAL CHEMISTRY.

ANIMAL SUBSTANCES.

Animals.

MAN in conſequence of ſuperiour organization, when compared with all other vital organized beings, has claimed the diſtinctive mark of placing himſelf at the head, and of forming a claſs peculiar to his own ſpecies, and almoſt all naturaliſts, ſince the time of Ariſtotle, have approved of the deciſion: the remaining part of the animal creation which ſo far exceeds him in number, has been divided by Daubenton, the French natural hiſtorian, into eight claſſes, viz. Quadrupeds, Cetacea, Birds, oviparous Quadrupeds, Serpents, Fiſh, Inſects, and Worms. Of theſe claſſes, very few have, at preſent, been ſubmitted to chemical inveſtigation; it is principally to the human ſubject, and the oviparous quadruped, that the reſearches of the analytical ſcience extend, although ſome ſlight attention has been paid to the oviparous quadrupeds, inſects, and worms.

Conſiſt of different parts.

Animals, it is well known, conſiſt of a variety of different parts, ſuch as blood, fleſh or muſcle, membrane, tendon, ligament, fat, nerve, perioſteum, brain, cartilage or griſtle, bone, hoof, horn, ivory, ſhell, hair, and feathers, together with other ſubſtances that give riſe to their colour, ſmell, and taſte. All theſe parts, as well as the ſecretions of different kinds, are formed from the blood by various proceſſes of the organized machine, from the nutriment received into the ſtomach; and by the ſame means theſe parts are conſtantly ſupported during the life of the particular animal. Whilſt this formation and renewal are going on, other matters are ſeparated, ſuch as urine, ſweat, and feces, which are excreted and evacuated from the living machine, in the form of uſeleſs excrement.

On taking a general view of all theſe parts and matters, as far as they have been ſubmitted to any chemical analyſis, they may be divided into

Diviſion of animal ſubſtances.

1. Fluids,
2. Solids,
3. Hard Parts,
4. External Parts,
5. Oils,
6. Acids,
7. Poiſons,
8. Aromatics,
9. Colouring Matter,
10. Concretions, and
11. Excrements.

Since the formation of theſe ſubſtances is for the moſt part derived originally from vegetables, and the manner of their converſion has not yet been aſcertained, it is ſuppoſed that an exact chemical analyſis of theſe parts, and a compariſon of their component principles with thoſe of vegetables, may be a means of caſting ſome light upon the operations and nature of the different functions, and lead to a more exact knowledge of the laws of the animal œconomy.

Imperfect ſtate of it.

Animal Analyſis.—The analyſis of animal ſubſtances is the moſt difficult and leaſt advanced of any part of chemiſtry. This neglect has been attributed to ſeveral cauſes, viz.—To the diſagreeable products that ariſe on ſubmitting them to experiment, which have been found ſufficient to repreſs the ardour of inquiry; the great want of proper means and methods to treat them; the impoſſibility of reproducing theſe matters, or the total abſence of every idea of ſyntheſis; and laſtly, the ſmall degree of intereſt which the chemiſt who was not a profeſſed phyſician took in the reſults of their analyſis. Such have been the principal circumſtances that have arreſted the progreſs of this part of the ſcience. The cauſes.

It was owing to theſe cauſes that the old chemiſts contented themſelves with the mere diſtillation of animal matters in the open fire; an operation which, it is now well known, entirely changes their nature and compoſition. It is to this ſcience, therefore, when it put on a more modern and philoſophic form, that we are to look back for the firſt traces of a more judicious method of analyzing theſe ſubſtances; and we are indebted to Margraaf, Rouelle, Prouſt, Macquer, Scheele, and Bergmann, for offering us a more extenſive view, and a deeper inſight into the principles that compoſe them. Antient method of analyſis.

The advantages, likewiſe, which a knowledge of the different gaſes preſented to the chemiſt, and that flow of light which the new French chemical revolution had expanded over a variety of phenomena hitherto obſcurely explained, or totally overwhelmed in darkneſs, enabled the chemiſt to purſue a different rout from what had been before attempted; and for the preſent appearance of animal analyſis, although ſtill in a very imperfect ſtate, we muſt have recourſe to the indefatigable induſtry, and the numerous and well conducted experiments of Fourcroy, Marqueron, Vauquelin, Parmentier, Deyeux, Stipriaan, Berthollet, Pearſon, Wollaſton, and Haggitt. New method.

Forſaking, or at leaſt not relying upon, the decompoſition of animal ſubſtances by fire alone, according to the old method, later chemiſts have tried the effects which thoſe chemical agents have upon them, which are known by the name of reagents, ſuch as the different acids, alkalis, alcohol, &c.; and they have been ſubmitted to the ſame operations as chemiſtry had made uſe of in the analyſis of other bodies, ſuch as ſeparation by repoſe, expreſſion, decantation, and filtration, either of thoſe fluids which are found mixed together, or contained in various parts of the more ſolid and hard animal matter. The action they have on the colouring parts has been likewiſe obſerved with great care, the different changes they undergo at different temperatures, the animal fluids have been evaporated, and the different ſalts they contain have been carefully extracted from them, without undergoing any alteration. By purſuing theſe methods of analyſis, the above chemiſts have made ſome very important diſcoveries in the animal kingdom, the component parts of ſome of it's matters have been expoſed, a difference has been found between animal and vegetable ſubſtances, and we are enabled to reduce them to ſome ſyſtematic arrangement.

It is by the new method of analyzing that almoſt every diſcovery has been made in animal ſubſtances, and to it we muſt have recourſe in the proſecution of further inquiries, in order to acquire a complete knowledge of their properties and compoſition.

Two kinds of analyſis.

On taking a general view of the action of chemical agents on animal ſubſtances, the means by which their analyſis and decompoſition are affected are either natural or artificial. The firſt comprehends their analyſis by putrefaction; the ſecond, by heat and by chemical reagents. The products which ultimately ariſe, and the new combinations that take place, are, generally ſpeaking, very ſimilar, and the principal difference between them is perhaps more to be attributed to their ſlower or quicker decompoſition, than to any intervening new ſpecies of matter.

1. By Putrefaction, or their ſpontaneous decompoſition, *vide* Putrefaction. Natural.

1. By Heat. The action of heat either accelerates their decompoſition alone, or when combined with other powers, giving riſe to new combinations. The gentle heat of diſtillation firſt ſends over an aqueous portion from an animal ſubſtance, with it's peculiar aroma. On increaſing the heat gradually, an empyreumatic oil ariſes, at firſt more or leſs yellow, at laſt more or leſs black, according to the degree of heat; then follows volatile alkali in it's liquid or dry ſtate; and when the heat is red or exceſſive, the aerial fluids are obtained, ſuch as fixed air, hydrogen gas, and a little pure air. The remaining portion is a black coal of difficult incineration, which on being lixiviated afterward, affords ſalts, ſuch as the phoſphats of lime and ſoda. During this proceſs, the animal matters undergo a total decompoſition, and the greater part of the products appear to be new combinations which did not previouſly exiſt in the matters, but are formed by the different unions of their component principles. Of the manner however in which theſe take place there are ſeveral opinions. According to the phlogiſtic ſyſtem, the elements of animal ſubſtances are for the moſt part pure air, phlogiſton, calcareous earth and water; when therefore a diſtilling heat is applied, the *air* and *water* yield firſt to the expanſive force of the fire, and conſequently the firſt products are principally compoſed of thoſe two elements; by a greater degree of fire, the phlogiſton is ſeparated from the earthy matters, and with a certain proportion of air, water, and earth, forms *oil*; the *volatile alkali* ariſes from the compoſition of another part of the phlogiſton, and from as much of it as can be

Artificial.

According to the old ſyſtem.

united with water by means of a little of the earth and air. *The acid liquors* are produced from another portion of the air with the organic elements, whilſt the *fixed air* only differs from the latter by it's air being combined with a leſs proportion of them; in the *inflammable gas* there is leſs air and more phlogiſton, it's being of the heavy kind ariſes from oily matter being diſſolved in it; the remaining charcoal conſiſts of the reſt of the phlogiſton, united with the greateſt part of the earth; and finally, the phoſphorus was ſtill to be accounted for, although it was conſidered as a compound ſubſtance.

According to the new ſyſtem.

According to the antiphlogiſtic doctrine, the origin of theſe products is explained in a different manner. Lavoiſier appears to have entertained two opinions reſpecting their formation, one of which he afterward abandoned, but as it was only the prelude to a more ſatisfactory method of explanation, it will be neceſſary to mention it. Berthollet and Fourcroy, and the other French chemiſts, were of the ſame opinion. Animal ſubſtances they aſſert contain neither water, carbonic acid gas, nor empyreumatic oil already formed in their compoſition, but only their elements; a degree of heat a little above boiling water is ſufficient to unite the hydrogen with the oxygen, and form water, and the hydrogen and carbon to form oil, whilſt the azot and hydrogen produce the volatile alkali. In theſe ſubſtances, as well as in vegetables, the carbon, Lavoiſier aſſerts, is in exceſs, which is the principal cauſe perhaps of their action on water; the carbon in exceſs attracts the oxygen of the water and forms carbonic acid gas, whilſt a portion of the hydrogen becoming free, is diſengaged, or combines with the carbon to form oil, or with azot, and forms ammonia.

Afterward Lavoiſier formed a new theory. He aſſerts, that three of the principles, viz. hydrogen and oxygen and azot, have a great tendency to unite with the matter of heat, and take the form of gas, whilſt the carbon is a fixed principle, and has very little affinity with the matter of heat, particularly when united with phoſphoric acid. If the temperature to which the ſubſtance is expoſed in diſtillation does not much exceed that of boiling water, the hydrogen and oxygen unite to form water, which paſſes over into the receiver. A portion of the hydrogen and of the carbon alſo unite and form the empyreumatic oil, which is more or leſs dark coloured, according to its quantity of carbon, whilſt another part of the hydrogen unites with the azot and forms the ammonia.

But if inſtead of a heat nearly equal to boiling water, a red heat be applied to an animal ſubſtance, water is no longer formed, or that water, if generated by the firſt effect of the heat, is decompoſed, the oxygen unites with the carbon to which it has a greater affinity at this degree of heat, and forms carbonic acid gas, and the hydrogen being diſengaged either unites with the azot to form ammonia, or part of it uniting with the matter of heat eſcapes in the form of hydrogen gas. At this degree of heat no oil is formed, or if formed would ſoon be decompoſed. The phoſphorus remaining combined with the carbon renders it fixed and difficult of incineration. Such are the general products and explanation of the decompoſition of animal ſubſtances by heat.

We are however informed of other products having been found during this proceſs of diſtillation, thus Berthollet found a peculiar acid, viz. the zoonic, and when animal ſubſtances have been ſubmitted to a very ſtrong degree of heat, it gives riſe to the formation of the pruſſic acid, and even phoſphorus.

2. By reagents.

The blue colours of vegetables are changed to a green by the principal fluids of animals, from their containing ſoda. Water by the aid of heat extracts the gelatin and coagulates the albumen of animal matters, whilſt the fibrin remains behind. The principle of tan precipitates the gelatin. Acids when diluted coagulate the albuminous part; unite with the ſoda, with which they form a neutral ſalt; diſengage the lime by decompoſing the phoſphat of that earth, and form with it an earthy ſalt according to the nature of the acid employed. They likewiſe unite with the oily parts. If the *ſulphuric* acid be uſed, the ſubſtance becomes blackiſh; if the nitrous, it takes a yellowiſh hue; and if the latter acid be aſſiſted by a ſlight elevation of temperature, it is ſufficient even in it's weakeſt ſtate to diſengage the azot in the form of gas. When in their concentrated ſtate the acids decompoſe animal ſubſtances by their corroding or cauſtic property, and during this action new compounds are formed.

The *ſulphuric* acid attracts their aqueous part, or if this be in ſmall quantity, a ſeparation of their principles takes place, the azot unites with a portion of hydrogen, and forming volatile alkali combines with the ſulphuric acid, or with a vegetable acid, which according to Vauquelin and Fourcroy is a new production, whilſt another part of the hydrogen forms with the oxygen that water which is requiſite to ſaturate the ſulphuric acid; at the ſame time the quantity of carbon, which exceeds that required with the hydrogen and oxygen to compoſe the new acid, remains in the form of a black coal, or if the ſubſtance be in a liquid ſtate, in the form of flocks or black powder. During this proceſs there is no evident eſcape of any volatile principle.

The action of *nitric acid* on animal ſubſtances is firſt to diſengage the azot gas from them, they become yellow, and there ariſes on their ſurface a kind of cryſtallizable, inflammable, and bitter varniſh; at the ſame time there is an adipoſe ſubſtance formed, which ſwims on the top when the mixture is become liquid, the carbonic and pruſſic acids ariſe in the form of elaſtic fluids, ammonia is produced which ſaturates the nitrous acid in part, and the ſubſtances thus reduced to a vegetable ſtate are found in the portion which remains fixed and liquified with the nitric acid, converted into oxalic acid, and ſometimes into the mucous and acetous acids. Another portion of the animal ſubſtance forms water, which is either reduced to a vapour or dilutes the ſalts and acids. In this account of animal decompoſition by the nitric acid, each ſubſtance is diſtinguiſhed and characterized by different reſults ; one affords a great deal of azot gas, little ammonia, and much yellow and fat matter; another gives little fat, and an abundance of vegetable acids; a third a deal of pruſſic acid; in a fourth the mucous or ſaccholactic acid formed is very abundant, whilſt others do not even ſhow a ſingle trace of it. Some likewiſe diſengage a great deal of carbonic acid gas, others decompoſe a great quantity of nitrous acid during their decompoſition; whilſt others, on the contrary, ſuffer their bond of compoſition to be diſſolved on the leaſt contact of a ſmall proportion of this acid. It is by theſe differences that the expert chemiſt may judge of thoſe which characterize the different animal matters.

The *muriatic acid* when combined with heat and applied to animal ſubſtances diſengages the azot and hydrogen forming ammonia, which by uniting with the muriatic acid gives muriat of ammonia, and hydrogen gas is likewiſe extricated towards the end of the proceſs.

Neither the ſulphuric nor muriatic acid acts with ſuch energy on animal ſubſtances as the nitric acid ſufficiently concentrated; and the reaſon why azot gas is extricated in the latter caſe, whilſt it unites with hydrogen in the form of ammonia in the former two, is conjectured to ariſe from the neceſſity of heat, ſo that the azot is in ſimilar circumſtances as when the animal ſubſtance is diſtilled, in which it combines with the hydrogen; one part of the hydrogen is obliged to take an elaſtic ſtate.

It is neceſſary to obſerve, that with the ſulphuric acid very little carbon remains, but a large quantity of carbonic acid gas is obtained; whilſt with the muriatic acid, ſince there remains a much larger proportion of carbon, it is to be preſumed that very little carbonic acid gas is diſengaged.

Alkalis, when in their mild ſtate, unite with animal acids, forming with them peculiar neutral ſalts. When in their cauſtic ſtate, Berthollet affirms, they diſſolve animal ſubſtances, by which their cauſticity is taken away; but according to Fourcroy, the diſagreeable putrid odour which Berthollet obſerved proves that ſomething elſe takes place beſides a ſimple combination. He therefore concludes, that when animal matters are put into a ſtrong cauſtic alcaline ley, ammonia and caloric are both diſengaged; that in proportion as this ammonia is formed the animal matter loſing thereby five times a greater quantity of azot than of hydrogen, contains in union with the alkali much more hydrogen than before, and thus contracting an oily character, it's alkaline combination is a real ſoap. Acids decompoſe it and ſeparate a concrete brown oil from it, whilſt earthy and metallic ſolutions form earthy and metallic ſaponaceous precipitations.

Lime, barytes, and ſtrontian earth act in the ſame way, but with leſs energy.

The calces of metals and metallic ſalts are likewiſe powerful cauſtics, but their action conſiſts in parting with their oxygen and forming a combuſtion, for which, vide *Cauſtics*.

Alcohol precipitates the albumen in the form of a coagulum and extracts their reſinous parts. Animal ſubſtances, when reduced to ſuch a ſtate as only to have their ſaline and earthy parts left, are finally examined like other ſaline and earthy bodies, which it is perhaps unneceſſary to mention in their general analyſis.

Encyclopedie Méthodique, article *Analyſe*.—Berthollet ſur la nature des ſubſtances animales, Mém. de l'Acad. royale, an. 1784.—Ker's Dictionary of Chemiſtry, 1 Part p. 186, 194, 195, Birmingham, 1789.—Lavoiſier, Réflexions ſur la décompoſition de l'eau par les ſubſtances végétales et animales, Mém. de l'Acad. p. 540, an. 1786.—Of the ſpontaneous action of concentrated ſulphuric acid on vegetable and animal ſubſtances, by Cit. Fourcroy and Vauquelin. Nicholſon's journal, No. 9. p. 272. Jan. 1786.—Précis d'obſervations ſur l'analyſe animale comparée à l'analyſe végétale, par M. Berthollet. Journal des Scavans, T. 28. p. 272. Jan. 1786.

FLUIDS.

In giving an account of the different parts of the animal body, it might perhaps appear more ſyſtematic to deſcribe them according to the priority of their formation; but this can only be done with reſpect to a few. Thus it may be ſaid, that the fluids are formed before the ſolids; the ſolids before the hard parts; and the laſt before the external parts; but it would be difficult to proceed further without much uncertainty: this rule, however, ought to be obſerved as nearly as poſſible. The various uſeful fluids of the animal body appear to be much leſs in quantity than the ſolids; and although Gaubius, as well as Cullen, was of opinion that they are formed from the ſolids, modern authors have reverſed the doctrine, and have defended the old ſyſtem of Harvey, by aſſerting, it is from the fluid blood that all the remaining fluids, as well as ſolids, derive their origin. The uſeful fluids which have been ſubmitted to chemical analyſis, may be divided into eggs, the blood, and its different ſecretions.

Eggs.

Eggs.—It is in the egg that we muſt look for the commencement of vital organization; but little is known of its developement, or the progreſs which the embryo makes as it verges towards perfection. Eggs may be diſtinguiſhed into two different kinds. 1. Thoſe defended by a hard external covering, called the ſhell, as the eggs of birds. 2. Thoſe which are only provided with a tough membranous covering, as the eggs of different ſnakes, and ſome of the oviparous quadrupeds.

The eggs of birds, which are the only kinds that have undergone any chemical inveſtigation, are compoſed of four parts, viz. 1. A bony ſhell. 2. A membranous pellicle. 3. The white; and 4. the yolk. With reſpect to the 1. and 2. they will be mentioned amongſt the hard and ſolid parts.

The White.

Neumann.

The white or albuminous part. This part of the egg is a thickiſh, tranſparent, adheſive, viſcid fluid. Neumann ranked it among the gelatinous ſubſtances, as poſſeſſing their viſcid and glutinous quality, but although like the gelatins it is capable of being uſed as a cement for glaſs and earthen ware, he thought it differed very materially from the other ſubſtances of that kind, at leaſt from thoſe extracted from the ſolid parts of animals, in being not ſoluble but hardened in boiling water. This coagulation by heat is ſince found to be one of the diſtinguiſhing characters of the white of the egg, by which it forms with ſeveral other animal matters, particularly the ſerum of the blood, a diſtinct genus, for which, vide *albumen*.

Properties of the white.

The white of the egg changes the ſyrup of violets green from its diſengaged ſoda. It is ſoluble in cold water, although it does not eaſily mix with it, on account of its viſcidity; thus 10 parts of water diſſolve exactly one part of white, and acids and alcohol precipitate it again in the form of coagula, as in milk. With aerated water the ſolution is imperfect, and the white from being perfectly tranſparent forms a few white ſtreaks, or becomes turbid, according to the quantity of air contained in the water.

Water when heated coagulates the white, before it comes to the boiling point; according to Fourcroy this takes place at 150°, but according to Leonhardi at 160° of Fahr^r. In this ſtate it has loſt it's tranſparency, is of a milk colour, and is now entitled to the name of white of egg with great propriety; it is alſo found to be more or leſs hard according to the degree of heat applied; thus it is harder when boiled in ſalt than in freſh water, and ſtill more ſo in oils. It has alſo loſt ſome of its weight, for Hoffmann informs us that a hen's egg of 2 oz. 1 drachm (*i. e.* ſhell little more than 1 drachm; yolk ½ oz. and white 1 ½ oz.) on being hard boiled loſt 1½ drachm, whilſt Neumann found that 6 drachms 25 grains of this coagulated white afforded, on being exſiccated, only 55 grains.

Although pure albumen is not ſoluble in boiling water, yet according to Fourcroy the proportion of water diminiſhes the tendency of the white to coagulation or ſolidity, by preventing the near approach of the particles; thus if it be beaten with about one half it's weight of water and then boiled, a much leſs hard maſs is obtained than if none had been uſed; and he affirms with Scheele, that if the quantity of water be greater, as for inſtance, if it be mixed with 10 parts, it is even ſoluble in boiling water, in which the combination reſembles ſkimmed milk or butter milk, a fluid formed for the moſt part of water and albumen in a particular ſtate, acids added coagulate it again as in milk. When eggs are freſh laid they are not ſo eaſily coagulated as others. White of the egg when left to itſelf, and expoſed to a moiſt warm air, very ſoon becomes thinner and thinner until it is putrid: it then reſembles urine in ſmell.

The white on being expoſed, a few days during ſummer, to the ſun, Neumann found was converted into a dry and hard maſs reſembling in conſiſtence and tranſparency yellowiſh gum arabic, and when ſmeared on a piece of paper or other ſubſtance by means of a bruſh, it gives it a tranſparent varniſh like that gum, when dry. Neumann found that ten drachms of the white was reduced on drying to 2½ drachms; this change and loſs of weight is attributed to it's being deprived of it's water, which Cartheuſer affirms compoſes nine parts of it. When dried it is ſtill ſoluble in cold water, and forms the ſame viſcous fluid as before. By diſtillation in a water-bath nothing is obtained but its water, and in proportion as it loſes this, it becomes harder and of a reddiſh yellowiſh colour, and reſembles horn. If it has been previouſly coagulated it recovers it's tranſparency. Expoſed on the open fire in a retort, to a ſtrong heat, there comes over a ſtinking empyreumatic oil with a great quantity of volatile alkali, and a coal remains as in other animal ſubſtances.

By ſublimation Deyeux obtained a little ſulphur from it. Acids coagulate it. Scheele has, however, obſerved that very diluted acids diſſolve it at the boiling point, and it is again precipitated by them in their concentrated ſtate.

It is diſſolved by cauſtic alkalis and lime water, and precipitated from them again by acids; as this takes place an hepatic ſmell ariſes, and the vapours blacken ſilver and ſaccharum ſaturni. Cheeſe having the ſame properties, Scheele looked upon this matter to be cheeſe in it's pure ſtate. With lime it forms a very hard cement.

Metallic oxyds, according to Fourcroy, as thoſe of mercury (which do not form a very ſtrong union with oxygen) thicken it on being agitated with it, whilſt the oxyd becomes horn; in twenty-four hours the white was found ſolid, and the oxyd almoſt black.

On digeſtion with iron it is ſaid to diſſolve a ſmall portion of it.

Alcohol coagulates it, but ſooneſt when warm.

Cauſe of coagulation of the white.

With reſpect to the cauſe of the coagulation of the white of the egg, there has been ſeveral opinions. Scheele thought it aroſe from caloric or the matter of heat. Waſſerberg that it aroſe from being deprived of it's water, as is the caſe when it is heated with alcohol, at the ſame time he thought a ſpecific aſtringent power was likewiſe neceſſary. Fourcroy is of opinion that it ariſes from the combination of oxygen which is favoured by the heat produced. He divided the white of an egg into two equal parts, to the one he added a ſolution of carbonate of potaſh, to the other cauſtic potaſh, and he found that ſulphuric acid joined to the firſt produced no coagulation, but formed a thick coagulum on being added to the other; hence he affirms that the ſulphuric acid when mixed with the liquid albumen diſengages a great deal of caloric from it, which by favouring the intimate combination of the oxygen, produces the coagulation. This effect is ſtill increaſed by the cauſtic potaſh, which unfolds much more caloric than the white itſelf does, and beſides by abſorbing the ſulphuric acid and preventing it's union with the albumen, the potaſh proves that it is the impreſſion only of the caloric that gives riſe to the concretion: when, on the contrary, the white is mixed with the carbonate of potaſh in ſolution, the ſulphuric acid joined in the mixture, attacking the ſalt, diſengages the carbonic acid, which takes away the caloric and is volatilized to the ſtate of gas; the white therefore ought not to undergo any alteration, and in fact it remains without being coagulated. From theſe and other facts, as that of it's being coagulated by oxyds, Fourcroy ſeems to ſuppoſe oxygen to be the grand principle of coagulation in the white. Againſt this chemiſt, however, Corradori brings other experiments. He covered the white of a very freſh egg with olive oil, and expoſed it to a heat of boiling water, and found the coagulation took place as if in the open air, although no air had the leaſt acceſs to it, or any elaſtic air raiſed the oil in order to eſcape, ſo that no decompoſition of the water took place. He is alſo of opinion, that oxygen gas is not even abſorbed by the white. He put ſome white into a branch of a crooked tube, and plunged them into boiling water. The white ſoon coagulated, and the water in the open branch being always at the ſame level, proved there was no condenſation of air, and the conſolidated white had juſt the ſame volume as when in a liquid ſtate. He remarks, that the coagulation always begins in that part which is the moſt diſtant from the air, or at the bottom of the veſſel. His opinion is, that it ariſes from a change produced by the ſolvent power of the caloric, in the diſpoſition of the integrant parts of the white to obey the force of coheſion.

Inſpiſſated white.

Hatchett has made ſome experiments on *inſpiſſated albumen*. He informs us, that as the albumen of the blood is mixed with gelatin and fibrin, and as it is with ſome difficulty that the albumen can be ſeparated exactly from theſe ſubſtances, he preferred that of eggs, as being pure and unmixed, and in order that it might be brought into a ſtate in ſome meaſure ſimilar to ſome ſubſtances which he had examined (for which *vide* Bone) he dried it after coagulation, in a veſſel which was heated to 212 of Fahrenheit, until it became perfectly hard, brittle, yellow, and ſemitranſparent like horn.

1. After digeſtion of a few hours, the tranſparent

horny pieces of albumen were ſoftened, and became white and opake, exactly like albumen recently coagulated. At the end of eight days, the water exactly reſembled that afforded by quill, nail, and tortoiſe-ſhell; for tanning principle had no effect, although nitro-muriat of tin produced a faint white cloud. The reverſe of this takes place in recent liquid albumen, for if the infuſion of oak bark be added to it in that ſtate, it immediately forms a precipitate, and nitro-muriat of tin does not produce any effect till ſome hours have elapſed.

2. By diſtillation, the coagulated dry ſemitranſparent albumen afforded ſimilar reſults to thoſe mentioned (in the art. *bone*) as obtained from tortoiſe-ſhell, &c.

3. A ſpongy coal of difficult incineration remained. That which was ſoluble in water, and which was by far the moſt conſiderable, conſiſted principally of carbonat, mixed with a ſmall quantity of phoſphat of ſoda, the reſt, as far as ſo ſmall a quantity could be aſcertained, proved to be phoſphat of lime.

4. When ſteeped in dilute nitric acid, in about four weeks the acid began to be tinged yellow, which gradually became deeper in three months, however the albumen, although leſs tranſparent, was but little diminiſhed. The yellow acid ſolution, when ſaturated with ammonia, changed to a deep orange colour, and remained tranſparent.

5. The albumen, thus ſteeped, was immediately immerſed in ammonia, which changed it to a deep orange, inclining to a blood red, and by degrees entirely diſſolved it; the ſolution was of a deep yellowiſh brown.

6. If the albumen, inſtead of being immerſed in ammonia, was waſhed, and then boiled in diſtilled water, it was diſſolved and formed a pale yellow liquor, which by evaporation formed a gelatinous maſs; this being diſſolved again in boiling water was (like gelatin) pre-

cipitated by the tanning principle, and more ſlowly by nitro-muriat of tin.

7. By concentrated nitric acid, or by the dilute when heated, albumen was ſpeedily diſſolved with much effervefcence, and a copious diſcharge of nitrous gas.

8. This ſolution was like that of tortoiſe-ſhell and the other ſubſtances (art. *bone*).

9. When evaporated it afforded ſimilar reſults.

10. Albumen, like tortoiſe-ſhell, quill, and nail, was diſſolved by boiling lixivium of cauſtic potaſh, and formed animal ſoap.

11. In like manner alſo a conſiderable portion of ammonia was diſcharged, and if the alkali was in exceſs, ſome coal was depoſited.

12. The animal ſoap obtained from albumen, when diſſolved in water, yielded a precipitate by the addition of acetous or muriatic acid; and the precipitate was rediſſolved when the acid was added to exceſs.

13. This precipitate, when collected on a filter, appeared more ſaponaceous and leſs viſcid than that obtained from the ſubſtances art. *bone*; for this precipitate when obtained from hair, wool, and muſcular fibre, appeared in ſome caſes more and in others leſs viſcid, although ſimilar in every other property. When gently heated, ſome oil flowed from it; after which, a browniſh viſcid ſubſtance remained, ſimilar in it's properties to that obtained from the animal ſoap made by tortoiſeſhell, &c.

14. He found that inſpiſſated albumen, long boiled with diſtilled water, was apparently diminiſhed; but the water (like that in which tortoiſe-ſhell, quill, or nail has been boiled) had acquired the property of becoming white and turbid, when nitro-muriat of tin was added, although it was not changed by the tanning principle. Likewiſe the water in which albumen, or

tortoiſe-ſhell, or nail, had been boiled, became, in ſome meaſure, putrid, in a few days, and emitted an offenſive ſmell. He, however, does not look upon this as a proof that any gelatin had been ſeparated from theſe bodies by means of boiling water, but rather that inſpiſſated albumen, tortoiſe-ſhell, &c. are ſubſtances really ſoluble, although in ſo ſlight a degree as to approach inſolubility; and that, thus, the prevalent opinion has ariſen concerning the inſolubility of coagulated albumen in boiling water. It does not putrefy in it's inſpiſſated ſemitranſparent ſtate.

Albumen, when merely coagulated, does not eaſily putrify, for Hatchett kept it, when it was ſoft, white, and coagulated, in water for a month, without it's becoming putrid; but that which has not been coagulated, but diluted with water, ſoon putrefies.

Berthollet, by means of the nitrous acid, extracted from the white a fat matter, and ſome ſaccharine acid.

Yolk.—This is a more or leſs yellow fluid, which in it's freſh ſtate poſſeſſes the central part of the white, and is of a globular form. It conſiſts of two parts, the one is an albuminous matter reſembling the white; hence it becomes coagulated and hard by expoſure to heat, acids, or alcohol, but leſs ſo than the white. The other part is a mild fat oil, which appears to exiſt in the yolk, in the ſame ſtate as the oil in the ſeeds of ſome plants, and it is this oil that forms a very ſtriking analogy between the eggs of animals and the ſeeds of vegetables. On this account the yolk is not entirely ſoluble in water, like the white, but forms with it a milk white fluid, which is called an emulſion, reſembling that produced from vegetable ſeeds, and for the ſame reaſon it diſſolves oily and reſinous bodies, and makes them miſcible with water. It Yolk.

likewiſe contains a conſiderable quantity of water, which is ſeparated on diſtillation.

It's oil. To obtain this oil, there are two ways: Firſt, by expreſſion. The yolk muſt firſt be deprived of it's water, by boiling; it is then to be put into a proper veſſel, upon a moderate fire, and kept ſtirring until it is obſerved to become ſomewhat ſofter, from the exuding of the oil; this is then to be preſſed out from the yolk, by putting it, in a little linen bag, between two warm plates; by theſe means Crantz found that fifty eggs afforded five ounces of oil. Secondly, ſince the heat neceſſary for roaſting produces a change, and a ſmell, Chandelier has found out a method of procuring the oil in a more perfect ſtate, and in larger proportion, without the aid of fire. Having well beaten the yolks, he put from two to three drachms of rectified alcohol to each, and diluted the mixture with ten times the quantity of water, in which he ſometimes diſſolved a very ſmall quantity of alum; he then let it repoſe twenty-four hours. By this method, from eight yolks he obtained six drachms of oil of eggs. This oil is of a yellowiſh colour, of a ſomewhat thickiſh viſcous conſiſtence, mild and inſipid; when, however, it is procured by means of heat, it's taſte and ſmell are ſlightly empyreumatic. It ſoon becomes fixed in the cold, and, according to Hildebrandt, it readily turns rancid. What remains of the yolk is albumen, from which, the laſt chemiſt has obſerved, a little gelatin may be extracted by water. The yolk, when boiled with cauſtic lixivium of potaſh, forms, according to Hatchett, a pale olive coloured concrete animal ſoap, which when diſſolved in water, and ſaturated with muriatic acid, is precipitated in the ſtate of mere fat. By incineration, the yolk affords a ſmall portion of the phoſphats of ſoda and of lime.

The yolk, from it's oily and albuminous nature, is uſed to unite oils, and oily ſubſtances, with aqueous fluids, forming *emulſions*, as they are called in medicine; which likewiſe forms a ſtriking analogy between eggs and the ſeeds of moſt vegetables.

Preſervation of eggs.

Eggs are commonly preſerved by packing them up very cloſe in bran, ſand, ſawduſt, and other ſubſtances that do not admit the free acceſs of air; the yolk, however, in theſe caſes, ſuffers a change, by becoming harder. Neumann kept an egg perfectly ſweet from May to November, in ſalt water; and Reaumur found, that eggs may be kept perfectly ſweet for years, by rubbing them *as ſoon as laid, with oil*, or other unctuous ſubſtances.

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Blood.

Blood.—Life, it is well known, depends upon a fluid which circulates through certain kinds of veſſels in all animals, and which the ancients very properly expreſſed by the name of the vital fluid. This has been, at all times, the ſubject of inveſtigation; and although, from the important part it acts in the general economy, by carrying life and heat even to the utmoſt extremities of the organized machine, there is no fluid which requires to be ſo thoroughly underſtood, or demands a more ſerious inquiry; the nature of the blood, and the laws that govern it's interior movements, in performing the offices it is deſigned for, have, at preſent, been but faintly developed; and the influence it has over the animal machine, during the various periods of exiſtence, may be even looked upon as entirely unknown.

Two ſpecies.

Phyſiologiſts, from the difference of colour of the blood in various animals, have diſtinguiſhed it into two kinds.

1. Red blood, which circulates in the arteries, and veins, and other parts, of the mammalia claſs, birds, amphibious quadrupeds, reptiles, and fiſh.

2. White blood, which is found in the greater part of worms and inſects, and has not yet been ſubmitted to chemical analyſis.

From this difference of colour in the blood, thoſe animals whoſe veſſels contain the red have been denominated ſanguineous; and thoſe containing the white, milky, or colourleſs fluid, exſanguineous animals.

The name of blood has likewiſe been uſed in a ſtill more extenſive point of view, and has been beſtowed upon that fluid which circulates in the veſſels of plants.

Firſt ſpecies, or red blood.

The firſt mentioned ſpecies alone has yet been analyſed. It is the moſt important fluid in the body, and as to it's component parts, whatever be the diverſity of the animal, whether it be an inhabitant of the earth, or of the water, or of the air, nature ſeems to have followed the ſame plan; it therefore affords no characteriſtic mark whether it be taken from the human body, a quadruped, a fiſh, or a bird; it always contains the ſame component parts. It is ſubject, however, to conſtant variety; it differs greatly, according to the regions through which it paſſes; it is not the ſame in the arteries and in the veins, in the ſtomach and in the region of the liver, in the muſcles and in the glands. It differs, according to the age, the ſex, the temperament, and the ſtate of health and diſeaſe. It is this variable ſtate of the blood, changing in the proportions and modifications of it's conſtituent parts, every moment, even in the ſame ſubject, that is the great obſtacle towards arriving at a perfect knowledge of it's nature and effects, and determining, by modern diſcoveries and chemical analyſis, the alterations it undergoes from the action of diſeaſe.

It's properties.

Blood, as it flows from the veſſels of a healthy animal, appears to be a red homogenous fluid; but, examined by the microſcope, ſmall flat balls are diſcovered, ſwimming in a thin, ſomewhat yellowiſh, liquid; and this is more particularly to be obſerved as it circulates in the veins of a living animal.

It differs, however, in colour, according to the part from which it comes; thus, in the arteries it inclines to a bright vermilion colour, whilſt, in the veins, it is of a deep purple. Even in the extremities of the ſyſtem, the blood of an artery is red, and that of a vein dark coloured; ſo that ſurgeons are able to diſtinguiſh arterial from venous hæmorrhages. The blood coughed up from the lungs is florid, whilſt that of the womb, of ſinuſes, of varices, and of all ſtagnant veins, is black and offenſive. The face is livid, in apoplexies, ſtrangulations, drowning, in fits of paſſion, or coughing, or in any accident that interrupts the circulation through the lungs. The face of a child is completely black during the paroxyſm of the hooping cough; tumours are dark coloured, from dilated veins that return their blood too ſlowly; and the mulberry, and other marks, which are born with us, are, according to Bell, ſmall aneuriſms full of ill oxygenated blood. The menſtrual blood, that of ecchymoſis, of aneuriſmal ſacks, are all black; and the blood of varices is ſo very dark coloured, as to make the ancients ſuppoſe they were filled with *atra bilis*, or black bile. With reſpect to it's quantity, in the human ſubject, Planck aſſerts that an adult contains about twenty-eight pounds of blood; four parts of which are allotted to the veins, and the remaining fifth to the arteries.

Blood is not ſo fluid as water, but has an unctuous or ſaponaceous feel, a ſweetiſh, ſaline ſavour, and it's aroma is ſomewhat urinous, fatuous, and peculiarly animal; which aroma is ſoluble in air, water, and ſpirituous liquors.

It's ſpecific gravity is greater than diſtilled water, being as 1053, or 1126 to 1000.

It's heat is different in the different orders of animals; human blood, and that of quadrupeds and birds, is about 96 of Fahrenheit, or 32 of Reaumur; whilſt, in oviparous quadrupeds, ſerpents, and fiſh, it is at the temperature of the medium they inhabit. The arterial blood is likewiſe warmer than the venous.

It unites with cold water, but boiling water coagulates it. Acids, when very much diluted, have no effect upon freſh blood, but, when concentrated, both the mineral acids and vinegar coagulate it, and change it's red colour to a dark brown.

According to Weber, the fixed and volatile alkalies change it's colour to a beautiful carmine red, without any coagulation; they even render it more fluid, particularly the latter. The fixed alkalies, when cauſtic, diſſolve it.

Lime water renders it more fluid, and increaſes it's colour.

Neutral ſalts, ſuch as nitre, common ſalt, &c. make it likewiſe more fluid, heighten it's colour and retard it's coagulation, whilſt alum and ſal ammoniac coagulate it.

Vitriols of iron and copper, particularly the latter, and ſpirit of wine when in a concentrated ſtate, likewiſe coagulate it.

If blood, recently taken from a vein, and either purple or black, be expoſed to oxygen gas, it changes to a vermilion colour, which however gradually diſappears and becomes again purple, and laſtly black, and no new impregnation can render it red again. On the contrary, if arterial blood, which is of a bright vermilion, be expoſed to air in which there is little or no oxygen, *i. e.* to unreſpirable gas, it's colour is gradually changed to a purple. *Vide* Reſpiration. Vaſſali of Turin found that blood as it comes from an artery or vein is in a ſtate of poſitive electricity, whilſt excretions, as urine, &c. are in a negative ſtate.

Spontaneous ſeparation in atmoſpheric air.

The blood, as ſoon as it is eſcaped from the veſſels, undergoes certain changes; if in a ſtate of repoſe, it firſt coagulates into a red gelatinous maſs; but it ſoon begins to ſeparate into two parts. One of theſe, which is red and ſolid, is termed the *coagulum* or *clot:* the other is a yellowiſh fluid, called *ſerum* or *lymph*, in which the coagulum ſwims.

In vacuo or unreſpirable gas.

If blood as it comes from the vein be put into a veſſel void of air, or filled with an unreſpirable gas, it likewiſe coagulates, but not ſo ſpeedily, nor to that extent as in atmoſpheric air, and the colour is rather black than red. On the contrary, if recent blood be put into a veſſel containing oxygen gas, the coagulation proceeds rapidly, and the colour is as red or more ſo than if it had been in atmoſpheric air. According to Beddoes, the reſpiring oxygen gas haſtens it's coagulation. It likewiſe coagulates more quickly when allowed to flow ſlowly from a vein, and in ſmall quantities; and more ſlowly when extravaſated in the cellular membrane, than when expoſed; in the laſt caſe this congulation firſt takes place on the expoſed ſurface, and on the edges of the diſh.

In oxygen gas.

Diſengagement of heat.

During the coagulation of blood, according to Fourcroy, a quantity of caloric is diſengaged ſo as to raiſe it's temperature 5°.

The coagulation prevented by agitation.

If blood be ſtrongly agitated by any mechanical means as it is received from the veſſels, this ſpontaneous change is prevented, nor can it be coagulated afterwards, according to Weber, either by acids, or alcohol, whilſt the alkalis heighten it's colour, and give it more or leſs tranſparency; it even becomes perfectly pellucid and fluid on the addition of the aqueous ſolution of ammonia, and it's colour is changed to that of the moſt beautiful cochineal. Agitated blood is likewiſe leſs inclined to the putrid fermentation.

It's putrefaction.

Blood readily putrefies, according to Weber, when expoſed to a temperature of 50° of Fahrenheit; it begins to have a diſagreeable ſmell on the ſecond day, which increaſes ſo rapidly as to be nearly inſupportable on the fourth; the coagulum then begins to change the ſerum to a darkiſh red colour, and it finally becomes ſo diſſolved as only to leave a few threads and lumps, and in this ſtate it has a ſtrong ſmell of volatile alkali.

Expoſure to heat.

Blood, when expoſed to a gentle heat, dries into a black maſs, termed the extract of blood. On diſtillation, it affords an inſipid phlegm, which quickly putrefies, an empyreumatic oil, and a neutral ammoniacal ſalt conſiſting of an acid, which is moſt probably the zoonic, superſaturated with ammonia. During this operation, the blood becomes very intumeſcent, evolves much hydrogen, carbonic acid gas, pruſſic acid, and by an exceſſive heat, a thick irritating ſmoke which is phoſphorus in a ſtate of combuſtion; and there remains a heavy ſpongy coal of difficult incineration, which when reduced to aſhes, affords carbonat and muriat of ſoda, phoſphat of lime, and oxyd of iron.

1. White ſerum.

Serum. This is a yellowiſh tranſparent liquor of a greeniſh tinge.

It's properties.

It is of an adheſive conſiſtence, has ſcarcely any aroma, but is ſomewhat ſaline to the taſte; according to Plenck, it forms ſcarcely half of the blood. On agitation it foams exceedingly.

The ſpecific gravity, according to Jurine, is to water as 28 to 1.

It is ſoluble in water to 55° of Reaumur, or 160° of Fahrenheit, when it coagulates. This is however prevented by dilution with water. In a coagulated ſtate it is of a white colour, reſembling boiled white of egg in odour and conſiſtence, and during it's coagulation a ſlightly turbid liquor ſeparates, which is *gelatin*.

It is to be ſeparated from it's ſolution in water by alcohol.

It changes the ſyrup of violets to a green colour.

Acids coagulate it when ſufficiently ſtrong, and the liquor remaining after filtration contains a neutral ſalt ariſing from the union of the acid and ſoda; but in ſmall quantity. It is alſo coagulated by alcohol.

Alkalis render it more fluid.

Serum does not decompoſe calcareous or aluminous ſalts, but it acts with ſufficient energy in the decompoſition of metallic ſalts.

It blackens the metallic ſplendour of ſilver.

During it's coagulation heat is diſengaged, and the cauſe of it's taking this concrete form is owing, according to Fourcroy, to the abſorption of oxygen.

Coagulated ſerum is inſoluble in water.

It is ſoluble in concentrated mineral acids, which ſolutions are decompoſed by water.

Cauſtic alkalis likewiſe diſſolve this concrete ſerum, and the ſolutions are decompoſed by acids.

By a moderate heat it dries into a corneous maſs.

Hence it appears, that coagulated ſerum is very ſimilar to the cheeſy part of milk.

Affords oxalic and malic acids.

If coagulated ſerum be treated with diluted nitric acid, by the aid of heat, nitrous and azot gaſes will be obtained, while the oxalic as well as a ſmall portion of malic acid will be found in the reſiduum.

Diſtillation. If fluid ſerum be diſtilled on the water bath, it affords an inſipid phlegm, and a coagulum remains. On increaſing the heat, it intumeſces greatly, and produces carbonic acid gas, liquid and fixed ammonia, and a thick empyreumatic oil; a large reſidual coal remains, which is with difficulty reduced to aſhes, containing common ſalt, carbonat of ſoda, and phoſphat of lime.

It's component parts. It appears from the preceding experiments, that the ſerum of the blood is the albuminous part of it, and that it conſiſts of albumen, a little gelatin, ſulphur, muriat and carbonat of ſoda, and phoſphat of lime. It is ſaid, that the gelatin is the acidifiable baſis which may be changed into malic and oxalic acids, but the albumen is the body that by dry diſtillation affords oil, and is chiefly diſtinguiſhed on account of it's property of coagulation by heat, on which account the blood of animals is uſed in clarification.

2d. *Coagulum or clot.* This has likewiſe been called the *Craſſamentum.* It is compoſed of two parts, which appear to have been partially ſeparated by a ſpontaneous action, but which may be entirely ſo by artificial means.

2. Red ſerum. If the coagulum be well waſhed in cold water, the red part is diſſolved by it, to which it communicates it's colour, and there remains a white fibrous ſubſtance which is the *fibrin* of the blood. The water thus tinged by the coagulum contains in reality all the colouring matter of the blood, and ſince when chemically examined, it proves to be the ſame as the white ſerum, except it's containing a great deal of iron, it may be called, in order to diſtinguiſh it from the other, the *red ſerum.* This iron is to be ſeparated from it ſeveral ways, by incineration, or by reagents.

Difference between it and white ſerum.

3. Fibrin. The fibrous part of the blood, or fibrin, having been

It's properties.

well waſhed off the red ſerum or colouring matter, is perfectly taſteleſs, and of a white colour.

It is inſoluble in water.

Expoſed to a moderate heat, whether by boiling or by other means, it becomes hard; and if this expoſure be ſudden, it ſhrinks up like parchment.

Cauſtic fixed alkalis only diſſolve it by the acid of ebullition, and cauſtic ammonia has no effect upon it.

Acids diſſolve it, and nitrous and azot gaſes are extricated during the ſolution, and it is precipitated from them by water and alkalis, in a changed ſtate.

On diſtillation in the dry way, it affords much aerated ammonia, and a very thick fetid and ponderous empyreumatic oil. The reſiduum, which is not very bulky, is compact, heavy, and eaſy of incineration. The aſhes are very white, and contain neither ſoda, neutral ſalts, nor iron, but they afford pure lime, and phoſphat of lime.

Expoſed to a moiſt atmoſphere, it very readily putrefies, ſwells, and affords a good deal of ammonia.

In inflammatory diſeaſes, it is partly ſeparated in the blood, and covers the coagulum in the form of a yellowiſh tough cuticle, commonly called the buffy coat of the blood.

Proximate parts of blood.

Hence it appears that the blood is capable of being ſeparated into three parts: 1. The white ſerum. 2. The red ſerum; and 3. the fibrin. Of theſe the white ſerum exiſts in the largeſt proportion, then the fibrin, whilſt the red ſerum forms the ſmalleſt portion; but they vary in their proportions, according to age, &c.

Remote parts.

If theſe three proximate parts be reduced to the utmoſt analyſis of which chemiſtry is capable, the remote component parts conſiſt of oxygen, azot, hydrogen, carbon, ſulphur, phoſphoric acid, ſoda, lime, and iron, to which may be added the peculiar aroma of the blood. It is to theſe few ultimate and indiviſible parts that the analytical ſcience has been able to reduce this rich and wholly animalized fluid, which appears to be the primitive principle of all animal ſubſtances, and the common origin of all the animal ſolids and fluids; and ſince it conveys, during it's circulation through the veſſels of the ſyſtem, the principle of life to every part, which on being deprived of it dies, and becomes ſubject to the laws of ſpontaneous decompoſition or putrefaction, the ancients were right in their aſſertions, that the blood was the vital fluid.

Having given a general view of the nature of the blood, of it's ſpontaneous ſeparation into it's proximate component parts, and the effects that the chemical agents have upon them, it will be neceſſary to trace the outlines of it's hiſtory, and the chief experiments of the principal authors who have enriched the ſubject by their diſcoveries.

Ancient analyſis.

The ancients were of opinion, that the vital fluid or blood, which of all the animal fluids is the moſt univerſally diſtributed throughout the body, was a compoſition of the other animal matters; and Hippocrates, perhaps, from it's reſemblance in colour to that of the muſcles, called it running fleſh; but they had not ſupported their conjecture by any chemical analyſis, and it would have remained as a mere fanciful opinion, had not modern experiments aſcertained, that the ancients were not very far from having aſſerted the truth. Before the time of Rouelle, very few chemical experiments had been made upon this fluid, and thoſe by no means ſatisfactory. With reſpect to the changes it underwent on expoſure to heat, they procured by diſtillation a water which they called *phlegm*. Vieuſſens found this phlegm to have very little odour or ſavour, and Homberg having procured fourteen parts from ſixteen of blood, thought that his experiments proved, on being compared with others, that

By diſtillation obtained phlegm.

this proportion of water was much leſs in plethora, gout, and ſcurvy, and increaſed in conſumption, and a phlegmatic temperament. On continuing the heat, Boyle obtained an oily and reddiſh fluid, of a bitter ſavour, and manifeſtly urinous nature, to which he gave the name of *ſpiritus ſanguinis*, which conſiſts according to him of volatile alkali diſſolved in the above phlegm. He got rather more than ſix parts from twenty-four of blood. Grew obtained, after this ſpirit, *ſal volatilis* in a ſolid ſtate, of a white colour, a ſtrong and penetrating ſmell, and effervеſcing ſtrongly with acid liquors. According to Needham twenty ounces of the extract of blood contain about two drachms of it, whilſt Verduc got one part from fifty-two of the extract. With this ſalt, but ſomewhat later, Boyle obtained a yellow oil, called the *oil of blood*, and by a ſtrong heat a pitchy oil that effervеſced with acids. This oil was ſuppoſed to ariſe from the fat part of the blood. From 179 parts, Vieuſſens obtained four parts of this oil. The remainder, after this expoſure to heat, was a ſplendid, light, ſpongy, black dreg, of a ſaline and bitter taſte, of an inflammable nature, which Helmont and Boerhaave called the *coal of the blood*, others the caput mortuum; this they found to contain earth, marine ſalt, fixed ſalt, oil, and a very heavy oil which was evident from the deflagration, and reddiſh aſhes compoſed of ſalt and iron remained behind. Hales likewiſe found an *aerial fluid* in blood, forming the 33d part of it.

Spiritus ſanguinis.

Sal volatilis.

Oil of blood.

Coal.

Aerial fluid.

With reſpect to the action of reagents on blood, it was aſſerted by Boerhaave and Schwenke, that vegetable acids made it thinner; and by Eller and Courten, that foſſile acids made it thicker or coagulated it. According to Boyle, alkalis rendered it more fluid, hence the neceſſity of taking acids to counteract it's fluidity; Queſnai, on the contrary, thought they thickened it. As to the neutral ſalts, Stahl aſſerted that nitre coagulated blood.

Action of reagents.

Neumann in his examination of this fluid obtained ſimilar reſults by diſtillation to thoſe of his predeceſſors, viz. an urinous ſpirit, a concrete ſalt and an oil. Lewis, who examined it more minutely after evaporation and inſpiſſation, found the exſiccated blood to be ſoluble neither in acid nor in alkaline liquors, that it communicated ſome colour to water and ſpirit of wine, and that it was more particularly acted upon by dulcified ſpirit of nitre. In his examination of recent blood, he found, that it was coagulated by the mineral acids, and by moſt of their combinations with earthy and metallic bodies; whilſt vegetable acids and ſolutions of neutral ſalts produced no coagulation: that it's fluidity was increaſed by alkalis both fixed and volatile, by which it was preſerved from coagulation: that the ſerum is not ſo much diſpoſed to putrefy as the craſſamentum: that it is ſomewhat more difficultly congealed by cold than pure water: that it coagulates by a heat a little greater than that of the human body: and that both this coagulum and the inſpiſſated ſerum are very inflammable in the fire, and inſoluble in water or ſpirit of wine, in acids or alkaline liquors.

Inſtead of making, however, any progreſs in the analyſis of this fluid, the attention of philoſophers was taken up in examining it's texture by means of the microſcope, and a variety of opinions was the conſequence, which will be found in the article *red particles.*

Rouelle publiſhed his work in 1773, and ſince this work appeared to the preſent time there is perhaps no fluid in the animal body, that has undergone ſuch a variety of inveſtigation, and been ſubmitted to more experiments than the blood.

As the microſcope was found to be of little uſe, chemical agents were reſorted to. After having treated this fluid by diſtillation, maceration, fermentation, &c. chemiſts had recourſe to other methods. At firſt, the ſaline taſte of blood made them preſume that it contained ſome kind of ſalt, but no one could account for it's coming there. The firſt idea was, that it's ſalt or ſalts were introduced by means of the aliments perfectly formed, but from want of knowledge, no one ſuſpected that nature was able to produce them in the animal as well as ſhe had done in the vegetable kingdom: in the determination therefore of theſe ſalts the opinion of chemiſts was for a long time divided. Some ſuppoſed that the ſalt was the muriat of ſoda; others pretended it was an alkali; and ſome even doubted of the preſence of theſe ſalts, ſince thoſe who admitted them, had obtained them only from the reſiduum of combuſtion, during the laſt effort of the fire to which the blood had been expoſed, whence they concluded that they were the products of combuſtion, and not component parts of this fluid.

There were ſome chemiſts who went even farther, and ſuppoſed that an acid as well as an alkali exiſted in the blood. Amongſt theſe particularly was Homberg, who aſſerted that this acid does not ariſe till towards the end of the diſtillation.

However fanciful the ſuppoſition was of it's containing an acid, it appeared however, and more particularly from the inveſtigation of Haller and de Haen, that different ſaline matters exiſted in this fluid. It was particularly to be obſerved from that of de Haen, that the water in which the coagulum had been waſhed gave evident traces of an alkali, and that exſiccated blood effervesced with acids, but it ſeems that the two chemiſts doubted of it's exiſtence. "Not one experiment," ſays one of theſe celebrated men, "is there to prove that "there exiſts pure and diſengaged ſalt in the blood, not "one phenomenon characteriſtic of acid or alkali." It therefore remained to determine after the ſlight veſtiges of an alkali, of what ſpecies it was, in what quantity it was preſent, and whether it exiſted in a free or united ſtate: this was effected by Thouvenel, but more particularly and ſatisfactorily by Rouelle.

Rouelle. Having made the obſervation, that not only the aqueous part of the blood or ſerum, but the water of all dropſical parts poſſeſſes the ſame properties as the white of egg, of being coagulated by moſt acids as well as by a boiling heat; likewiſe of uniting with water and changing the blue colour of violets to a *green* in the ſame manner as if a little alkali had been put into the water; Rouelle concluded, that as the water ſeparated from blood by diſtillation had no effect on the ſyrup of violets, except after having been kept ſome time, the property of changing the vegetable ſyrup did not proceed from any alkaline nature of the ſerum, or from it's volatile alkali, as ſome writers had ſuppoſed, but from a real diſengaged fixed alkali. He ſupported this aſſertion by the properties of the more or leſs coloured maſs remaining after diſtillation of blood. This which is pulveriſable, and reſembles externally a glue, but differs from it by being difficultly ſoluble in water, is found in time to have it's ſurface covered over with a cryſtallized ſalt, whilſt the maſs has regained it's tenacity by attracting moiſture from the air. But he proved by experiment that the blood contained this uncombined alkali; for on taking a quantity of ſerum either of the blood or from a dropſy, adding to it twice as much diſtilled water, and then mixing a little vitriolic acid with it and diſtilling it to dryneſs, he found, that on adding ſome boiling water to the remainder, and ſaturating the acid liquor, or rather the ſuperabundant vitriolic acid with chalk, a real *Glauber's ſalt* was obtained. Inſtead of the vitriolic acid he uſed diſtilled vinegar, and the conſequence was acetated ſoda. Hence the ſerum contained mineral alkali. In 1776 Rouelle publiſhed ſome other experiments on the ſaline matters which the blood contain. They were made on that taken from different animals, ſuch as the human, the ox, the horſe, the calf, the ſheep, the pig, the aſs, and the goat. In theſe, he proves, that the calcined aſhes contained in the blood of a healthy perſon afforded natron or mineral alkali, common ſalt, digeſtive ſalt in ſmall quantity, an animal or calcareous earth, iron and a coal. He found that theſe were in various quantities, 28 or 29 parts of alkali to 16 or 17 of the neutral ſalts, whilſt the animal earth formed the 10th part, and the quantity of coal was very inconſiderable. That on diſtillation and cryſtallization of the aſhes, the common ſalt was firſt obtained, then the digeſtive, and afterward the natron or baſis of common ſalt, and that the proportions of theſe were never the ſame in every ſort of blood. Such are the experiments of this celebrated chemiſt on the ſerum of the blood, by which he for ever fixed the opinion of it's containing ſalts, ſuch as ſoda and the muriats of potaſh and ſoda.

Bucquet.

After Rouelle, the next chemiſt of any conſequence is Bucquet. He communicated his experiments to the Academy of Sciences, amongſt which are ſome intereſting obſervations upon the different alterations the blood undergoes in it's ſpontaneous decompoſition. According to this chemiſt, the coagulation of the *ſerum* or lymphatic part of the blood is not occaſioned by the loſs of it's aqueous part or by exſiccation, but is produced by the peculiar action of heat. He found that the water of diſtillation was at firſt taſteleſs, and did not affect ſyrup of violets; yet that it was not pure, but contained animal matter, ſince it became putrid in time, and changed the ſyrup to a green from the volatile alkali that was extricated. He found that on diſtilling the exſiccated ſerum it afforded a volatile alkaline ſpirit, fixed volatile alkaline ſalt in large quantity, and an empyreumatic oil, the greater part of which ſunk beneath the ſpirit. The remaining coal was light and ſpungy, and nearly filled the belly of the retort, and afforded a great deal of common ſalt and fixed mineral alkali. It was difficult of incineration, and contained an uncommonly ſmall quantity of iron when the ſerum was free of any red part. He likewiſe found that the ſerum mixed in all proportions with cold water. If poured into boiling water one part was coagulated, whilſt the other formed a kind of union with the water; he does not however think it was a perfect ſolution, for it remained white and ſomewhat milky, and could not be rendered clear by repeated filtration. If boiled, it ſwelled, and a pellicle aroſe on it's ſurface as is the caſe upon milk, and the addition of acids or alcohol coagulated thoſe parts that prevent it's tranſparency.

It was ſtrongly diſpoſed to putrefaction, for having expoſed a little of it to the air it became putrid in ſo ſhort a ſpace of time, as to prevent his being able to determine whether it had previouſly undergone the acetous fermentation.

From other experiments made upon it, it appears, diluted acids coagulated it, and by filtration a fluid was ſeparated, which was eaſily diſſolved by the concentrated nitrous acid after having been firſt coagulated by it. This ſolution was accompanied with a ſtrong effervefcence, and the diſſolved part was precipitated by water.

Alkalis did not coagulate the aqueous lymphatic part of the blood, and even the cauſtic volatile alkali eaſily diſſolved it when coagulated. This ſolution was decompoſed again by any of the acids.

The neutral ſalts, whether with an alkaline or earthy baſis, had no action on this fluid part; but almoſt all thoſe with a metallic baſis cauſed a conſiderable precipitation.

With reſpect to alcohol, it has been already obſerved that the ſecond part, even that which unites with water, is coagulated by it; but it is a curious circumſtance that the ſame coagulated part is capable of again being diſſolved, and in pretty conſiderable quantity, in water, which is not the caſe with that which has been coagulated by acids.

The analyſis of the ſerum being once known, it remained to examine the coagulum, the red colour of which had given riſe to much diſcuſſion, and ſince the inveſtigation of the red particles forms an æra in the hiſtory of microſcopical obſervation, it is neceſſary to give ſome account of their examination.

Red particles. Lewenhoeck.

The diſcovery of the red particles in the blood was made towards the end of the laſt century. Lewenhoeck was the firſt who, having expoſed the leg of a frog to the lens of a microſcope, affirmed that the living blood conſiſts of a number of red globular particles ſwimming in a large quantity of a tranſparent liquor. Elated with this diſcovery, he enjoyed himſelf in the regions of fancy, and imagined that each of theſe globules was compoſed of ſix ſmaller ones packed together, that while the ſix continued to adhere, their colour was red, but being ſeparated, they became yellow and formed *ſerum*. His imagination carried him further, and he pretended that each of theſe ſerous globules conſiſted of ſix ſmaller ones, which when ſeparated formed a more ſubtile and penetrating liquor, than the ſerum itſelf. This theory, wild as it may ſeem, gained many admirers; it was even acknowledged as founded on facts, ſerved to advance other theories, and gave riſe to elaborate calculations, which now only ſerve to amuſe the curious.

Father della Torre.

The great confidence which had been given to microſcopical inveſtigation invited other philoſophers to examine the blood, and about the middle of the preſent century Father della Torre, on examining the red particles, found them to be of an annular figure, with a perforation in the middle, and the ring itſelf to be formed of ſeveral joints. The wonderful degree of magnifying power, however, which the lenſes he made uſe of were ſaid to poſſeſs, rendered the accuracy of his experiments doubtful, and ſome of them having been examined by the Royal Society, who failed in making ſo ſucceſsful an application of them, the credit of this philoſopher's diſcoveries reſted on his own evidence.

Hewſon.

To Father della Torre ſucceeded Hewſon, who very carefully purſued a ſimilar rout. He found, contrary to Lewenhoeck, that the red particles of the blood, when examined by the microſcope, were flat in all animals, and conſequently improperly called *globules*, and that they were of very different ſizes in different animals. In man they are ſmall and flat as a ſhilling, with a dark ſpot in the centre. In order to examine them with more diſtinctneſs, he diluted the blood with freſh ſerum, which precaution having been omitted by his predeceſſors, they were only able to ſee them very indiſtinctly. As to the black ſpot, the particles of the human blood being very ſmall, he found it difficult to determine, whether it was a perforation, as ſome imagined, or not: but he diſcovered in the frog, where it is ſix times larger than in man, that it was a little ſolid body contained in the middle of a veſicle. Inſtead therefore of calling the particles of blood red *globules* he thought red *veſicles* would be more proper, each particle being a flat veſicle with a little ſolid ſphere in it's centre.

He found the blood of all animals contained veſicles of this ſort. In the human and that of quadrupeds there are millions of them, and they give it the red colour. In inſects they are white and leſs numerous in proportion. He found that their flat ſhape was alterable by mixing them with different fluids, and that it is by a determinate quantity of neutral ſalt contained in the ſerum, that this fluid is adapted to preſerve them in their natural flat ſhape; for if mixed with water they become round and are perfectly diſſolved, but on the addition of a little of any neutral ſalt to the water, they remain in it without any change of form, or without ſolution; hence Hewſon ſuſpected the ſhape of theſe particles to be a circumſtance of ſome importance. He found that on diluting the blood of a frog or toad, with the ſerum of the human blood, the particles which are large became flat, as is the caſe in the veſſels of that animal, whilſt a little water firſt made them round, and then began to diſſolve them; a neutral ſalt gave them their flat ſhape, but if this was not added, the veſicle was gradually diſſolved by the water, and the little ſphere was left alone. He found that the particles in the blood of inſects, whether aquatic or earthy, were ſimilar in figure to that of other animals, but differed from them in colour. Such are the microſcopical obſervations of this celebrated phyſiologiſt.

A more laborious inveſtigation of the figure and ſize of theſe red particles has been made by Cavallo. He defends the falling credit of Father della Torre both with reſpect to the inſtruments he uſed and his experiments. He does not find that any lenſes or globules of very great magnifying power were uſed before the time of that philoſopher, who conſtructed them of wonderful minuteneſs, and at the ſame time clear and diſtinct, and it is from the great difficulty in their conſtruction, and in their uſe as magnifiers, that he attributes the cauſes why ſo few have repeated della Torre's experiments, and why moſt of them have been unſucceſsful, which want of ſucceſs has thrown ſuch ſuſpicions on his experiments and obſervations. Cavallo after much trouble ſucceeded at laſt in conſtructing a few microſcopical globules after his method, and having repeated his experiment on theſe globules with an apparatus made expreſsly for ſuch delicate work, Cavallo.

he found the deſcription that della Torre has given of the appearances to be very accurate, although his conjectures may have been ſometimes crude or miſtaken.

From the experiments of Cavallo it appears, that the mean ſize of the red particles differs very little in perſons nearly of the ſame age; that they differ ſomewhat in the ſame perſon; and that their figure is not very circular: but this deviation from the circle is not ſuch as a flat circular ſurface would aſſume in it's different inclinations to the axis of viſion, for the flat circular ſurface (according to the rules of orthographic projection) muſt appear either circular, or elliptical, or as a ſtraight line, whereas this experimentaliſt never perceived theſe red particles to form ſtraight lines, *i. e.* edgewiſe, and the elliptical figure they ſometimes aſſume is by no means regular.

In an adult perſon he found the diameters of the red particles from 0,0003 to about 0,0004 parts of an inch, and ſeldom ſmaller or larger. If therefore the ſmalleſt of them were ſet in a row, 3334 will be equal to one inch, and if the larger, about 2500.

When theſe particles are magnified more than 40 or 50 times, and leſs than 80 (in diameter) they appear like colourleſs tranſparent ſpots, encloſed within dark circles.

When magnified more than 80 and leſs than 160, a dark ſpot appears in the centre of each, reſembling a dot made on paper with ink. He found that if the reflector that illumines the particles, inſtead of being placed before the object, be ſet on one ſide of the axis of viſion, ſo that the light may be obliquely thrown on the object, one half of the dark circle of each particle diſappears, which is that on the ſide oppoſite the reflector. At the ſame time, the central ſpot appears to change it's place. When the particles are magnified about 200 times, the central ſpot appears converted into a circle encloſing a tranſparent ſpace. The diameter of this inner circle equals half of that of the external one, but the proportion of theſe diameters, or the ſize of the internal circle, may be brought to increaſe or decreaſe by the leaſt alteration of the diſtance between the object and the lens, and by the ſame means the ſpace within the inner circle may be rendered clearer or darker than that between the two circles. The poſition of the inner circle is changed by the direction of the light: for if the particle of blood be viewed through a microſcopical globule of glaſs directly facing the flame of a candle, without the intermedium of any lens or reflector, the inner circle will appear concentric with the outer one; but if the candle be moved a little to one ſide, that the light may fall obliquely on the particle of blood, the inner circle will be obſerved to move towards the oppoſite ſide, and to acquire an elliptical ſhape.

When the particles of blood are magnified above 400 times, an imperfect image of the candle, which is placed before the microſcope, may be ſeen within the inner circle of each particle. Through a glaſs globule of 0,018 of an inch in diameter he has ſeen the red particles magnified about 900 times, in which caſe the image of the flame of the candle could be ſeen within the inner circle of each particle very clearly, at leaſt ſo as to ſhow to which ſide the motion of the air in the room inclined it. Although the magnifying power was ſo great, yet the annulus or ſpace between the two circles did not appear to be divided, except ſome accidental fractures ſometimes ſeen in a few of the particles.

From theſe obſervations, this philoſopher thinks that the red particles of the blood are not perforated, but that they are globular, and compoſed of ſome uniform ſubſtance much leſs tranſparent than glaſs. They likewiſe ſhow that Hewſon's idea of their containing a central body, or nucleus moveable within the external ſhell, aroſe from the apparent change of place which the various direction of the light produces on the central ſpot or inner circle of each particle.

On the ſuppoſition of theſe red particles being globular, he expected to find that globules of other tranſparent matter would exhibit the ſame appearances, and his expectations were in great meaſure verified. The ſhades of difference he obſerved between them were: Firſt, that the glaſs globule ſhowed a diſtinct, whilſt the red particle ſhowed an indiſtinct image of the candle: Secondly, that the inner circle of the globule is much ſmaller in compariſon with it's external boundary than the inner circle of the particle is, compared with it's external one: Thirdly, that the annulus is uniformly dark in the globule, whereas in the particle it is as clear or clearer than the internal ſurface.

On examining theſe particles in the living animal, if any thin and tranſparent part, ſuch as the tail of a ſmall fiſh, or the membrane between the toes of a frog, be viewed through a good microſcope, the circulation of the blood through them is only perceived by the motion of theſe red particles, which follow each other at a greater or leſs diſtance, although in general, each particle ſeems to touch, or nearly ſo, the following one. They are never ſeen to run into each other and incorporate, and though not very hard, they are poſſeſſed of a certain degree of conſiſtency and elaſticity, for in paſſing through the very ſmall veſſels, they are frequently ſeen to aſſume an elliptical ſhape, whilſt from the ſmalleſt veſſels they are abſolutely excluded.

By labour the red particles may be accumulated in a wonderful degree; thus, in hard-working people they abound, and by the exerciſe of particular parts the ſame takes place, as in the wings of thoſe birds accuſtomed to fly, and in the legs of thoſe accuſtomed to walk a great deal. They are numberleſs in health and in all ſtrong creatures, whilſt in diſeaſed and weak animals they are in ſmall quantity.

Cavallo, on continuing his experiments on the red particles, found that they loſe their ſhape and are diſſolved in certain fluids, that this does not take place in the ſerum of the blood or in urine, except when left in theſe fluids for ſeveral days, or when theſe fluids are diluted with water. But water alone he found to be a powerful and almoſt inſtantaneous ſolvent for them, although it may be deprived of this property by the addition of common ſalt, or nitre, or of any other neutral ſalt, as well as by the admixture of a very ſmall proportion of the vitriolic acid. He found that the marine acid, when much diluted with water, had no ſolvent effect upon them, but it's action deprived them of their colour. Vinegar is likewiſe a powerful ſolvent, but not equal to water. He found that when once they were dried or diſſolved in water, they were not capable by any means of reſuming their former ſhape: and it appears that their formation even in the animal body is accompliſhed with great difficulty, at leaſt much leſs expeditiouſly than that of the other component parts of the blood; for in thoſe animals that have loſt much blood, although the ſanguiferous veſſels are ſpeedily filled with red blood, yet it continues thin and pale for a conſiderable time, and when examined by the microſcope, few red particles are to be found in it. This ingenious philoſopher does not attempt to offer any further conjectures reſpecting the nature and conſtruction of theſe particles.

Their colour.

The next circumſtance to be conſidered is their colour. It was ſuppoſed by the ancients that there was only one kind of blood; thus Eraſiſtratus taught that the veins contained the blood, whilſt the arteries only contained a ſpirit. Galen, however, ſpeaks of the blood on one ſide of the heart being more florid than on the other, which florid blood was the arterial. The celebrated Harvey, and the firſt believers of the circulation, were of opinion that there was no difference between the arterial and venous blood, either in colour, denſity, or in their elements. Some time after Harvey, when the ſubject of the redneſs of the blood came to be inveſtigated, it gave riſe to many diſputes. Some pretended, as the microſcopiſts, that it aroſe from the reunion of a certain quantity of globules, and the colour diſappeared on their being divided. Hoffmann thought he had found the cauſe in the union of the alkali with the ſpirituous matter, which he ſuppoſed to exiſt in the blood. Other chemiſts attributed it to different ſalts, and it was obſerved by Senac, in his work on the heart, that ſalts might augment it's red colour without increaſing it. After making various obſervations, he relates that the arterial blood is always of a more red and lively colour than the venous; that this colour is the more exalted as the action of the arteries is the more violent; that in young people it is more red and high coloured than in old: and theſe obſervations were ſufficient for ſome authors to find the cauſe of the redneſs in the action of the veſſels, in the multiplicity of the globules, and in the ſeparation of the lymph; but the numberleſs objections to which theſe theories were expoſed ſoon made it neceſſary to form more ſatisfactory explanations.

Several old authors had obſerved that blood, when agitated in the open air, immediately acquired a redder colour than before; and this act, which till now had not appeared to be very intereſting, immediately fixed the attention of phyſiologiſts, and there was reaſon to believe that it might lead to the cauſe. Hewſon, after many careful experiments, announced, although it had been done before him, that the combination of the air with the blood was ſufficient to colour this fluid. The only difficulty now was to indicate what body it was in the blood, that the air principally fixed upon in order to become the colouring principle, and this difficulty was ſoon taken away on recollecting that the blood contained iron. This diſcovery is due to Badia, who is ſaid to be the firſt that found iron in this fluid, and all opinions united and agreed to conſider the combination of iron with the air as the cauſe of the red colour. Iron.

Experiments of Menghini.

Menghini is the chemiſt who appears to have the beſt followed the conſtant and uniform track of nature, relative to the diſtribution of this metal in blood, the preſence of which deprived of it's colouring part, is a fact equally important as the diſcovery of a free alkali. Some chemiſts ſuppoſed, and amongſt theſe were Geoffroy, that this metal being found in the aſhes of blood was the effect of the fire; others, as Lemery, pretended that it was already formed in the blood, and that the fire only expoſed it by deſtroying the bodies with which it was mixed; whilſt others believed it to be the production of the veſſels in which the combuſtion of the blood had been made. Amidſt theſe doubts and conjectures, Menghini continued to ſeparate the iron without the aſſiſtance either of calcination, or any inſtrument the influence of which might be ſuſpected: the method he made uſe of was to dry ſome blood by a ſtove heat, and he found that the powder obtained, when expoſed to the loadſtone, became very ſenſible to the magnetic impreſſion. He found that there was a more conſiderable quantity in the human blood than in that of quadrupeds, that there was leſs in fiſh, and ſtill leſs in that of birds: and he concludes, that in the animal body the blood is the only true receptacle for it, and the experiments and obſervations which have been made, ſince thoſe of this learned

Italian chemiſt, have confirmed and developed the truths that are eſtabliſhed in his works.

Rouelle had likewiſe paid particular attention to the examination of the *coagulum* of the blood; but a premature death interrupted his labours, and deprived the ſcience of chemiſtry of one of it's moſt diſtinguiſhed votaries. This examination, indeed, required both phyſiological and chemical knowledge, and Bucquet, who appears to have united both with a great deal of induſtry and perſeverance, is the next author to whom we are to look for information.

Bucquet. This phyſician, whoſe experiments on ſerum have been already related, has likewiſe made the *coagulum* the ſubject of his reſearches.

The coagulum, according to this chemiſt, is compoſed of two parts, the *fibrous matter* and the *ſanguineous globules*. He conſiders the fibrous matter as having the greateſt tendency to become concrete of all the circulating fluids, and he thinks, that when once coagulated, it cannot be diſſolved by water. The ſmalleſt degree of warmth is ſufficient to harden it in a peculiar manner, and before it has even loſt it's moiſture. It then immediately becomes of a dirty gray colour, diminiſhes in volume, and becomes contracted like parchment. It gives on diſtillation nearly the ſame products as the ſerum, but the remaining coal is much thicker and more ſolid. If it be well waſhed before diſtillation, the coal contains neither common ſalt nor mineral alkali. It is much eaſier incinerated than the coal from the ſerum, and it's very white aſhes contain neither ſalt nor iron.

He found that this fibrous part was not to be diſſolved by boiling water; but became rather hardened and of a gray colour. It is likewiſe ſoluble neither in alcohol, oils, yolk of egg, alkalis, nor in the cauſtic volatile alkali, which ſo readily diſſolves the coagulum of the ſerous part; but is eaſily diſſolved by all the acids, even by vinegar, and it may be again ſeparated from them either by water, or ſtill better by alkalis. Theſe properties are very curious, and according to this chemiſt, reſemble moſt of the properties of the glutinous part of flower, and of the caſeous part of milk.

With reſpect to the red part of the coagulum, or red globules, they may be eaſily ſeparated from the fibrous part by ſimple lotion, and the tranſparency of the coloured liquor announces a perfect ſolution of them. In this ſtate he thinks it differs very little from the ſerum, except in colour. It is like the ſerum coagulated by heat, by acids, and by alcohol, and is ſoluble in volatile alkali, and affords the ſame products by diſtillation. It's coal is likewiſe equally light, contains common ſalt and mineral alkali, and is of difficult incineration. He has however obſerved that the cinder or aſhes have their brown red colour from the iron they contain; it reſembles the colour of the ſaffron of Mars, and is in large quantity. In his idea, therefore, of the coloration of blood, he has adopted the ſentiment of Menghini. He alſo believes that the want of colour, or the decoloration of this fluid in certain chronic diſeaſes, is owing to the abſence of this metal, and that the colour is again to be reſtored by the uſe of martial preparations.

Although the ingenuity of chemiſts, particularly of Bucquet, had made great progreſs in the examination of the blood, they had not found out under what form it was that the iron exiſted in it, nor was there any more certainty to be collected from the idea of Sage, who conjectured that it was preſent in a ſtate of combination with the phoſphoric acid. Sage.

At the time Bucquet publiſhed his experiments on this important ſubject, a revolution was preparing in the ſcience of chemiſtry, which, by adding new ideas on the compoſition of bodies, to thoſe that had been already received, muſt neceſſarily conduce to the diſcovery of new means to examine them. It was in conſequence of this event that chemiſts began to be convinced, that the fluid products obtained in the receivers, by diſtillation, were not alone deſerving their attention; but that, to gain a more perfect knowledge of the component parts of bodies, it was likewiſe neceſſary to direct their examination towards the volatile and aerial parts, which hitherto had eſcaped their obſervation, or, at leaſt, had been very little attended to. The knowledge which had been attained by the promoters of the new chemical doctrine, reſpecting the compoſition of the atmoſphere, and the diſcovery of new gaſes, was the principal means which ſome chemiſts made uſe of to explain certain facts which occurred from the examination of the blood; and they more particularly applied it in the explanation of the cauſe of it's red colour, as well as of ſeveral other properties that characterize it.

Having determined, pretty exactly, the component parts of the atmoſphere, the next circumſtance to be attended to, previous to the explanation of the phenomena which the new method of examining bodies offers, was to know how this aerial fluid acted during reſpiration, which may be found, in detail, at the article *reſpiration.*

During this proceſs it was ſaid that one part of the oxygen, or vital part of the atmoſphere, combines with the venous blood, and changes it's colour to a vermilion; a ſecond portion of the oxygen unites with the carbon contained in the carbonated hydrogenous gas of the venous blood, and forms carbonic acid gas; a third part unites with the carbon of the mucus of the lungs, and this part, likewiſe, forms carbonic acid; a fourth part combines with the hydrogenous gas of the blood, and forms water, which exhales during expiration; with reſpect to the caloric, which was looked upon as a material ſubſtance, one part of it, which the decompoſed vital air contains, remains united with the oxygen; another part of the caloric enters into combination with the carbonic acid, to form a gas, and the third part produces the temperature to form the water, by the combination of the hydrogen and oxygen gases.

The firſt chemiſt who has enlarged our views on the nature of the blood, and who examined it according to the principles of the new ſyſtem, is Fourcroy. This celebrated chemiſt has opened a new rout on this ſubject, and he begins his inveſtigation at the moment this fluid flows from the veſſels.

Fourcroy.

He found that, on agitating pretty briſkly all the parts of the blood, as it comes from the veſſel of an animal, and, for ſome ſhort time after, it's coagulation is prevented; the only ſubſtance that ſeparates is a ſpongy matter, of a flocky appearance, which ſwims on the ſurface. As blood is uſed in ſeveral of the arts, this method is uſed by the butchers previous to their ſelling it.

He found that blood, after having been drawn from the body of the animal, remains at 20° of the thermometer. At the moment of it's coagulation, according to this chemiſt, a quantity of caloric is diſengaged, which, by raiſing the temperature 5°, makes the thermometer be at 25°.

Agitated blood, the principles of which have been prevented from ſeparating, on cooling coagulates at 55° of Reaumur. During this coagulation, a number of air bubbles ſeparate, which remain adhering to the ſide of the veſſel; likewiſe in the internal part a number of cells is obſerved, which muſt have originated from ſome elaſtic fluid that had been diſengaged. This coagulated maſs has an odour and conſiſtence very much reſembling thoſe of the white of a boiled egg, and is of a grayiſh pearl colour. During this coagulation a milky or rather opaline coloured fluid is ſeparated, which froths very much on agitation, and changes vegetable blues to green.

If this agitated blood be expoſed to dephlogiſticated air, in a very few hours it becomes of a more lively red than before. A few days after it had acquired a beautiful purple, and on agitation it changed to a beautiful ſcarlet red colour. Being ſtill expoſed, it became of a deep colour like that of the leys of wine, and it was with great difficulty it reſumed it's former ſcarlet colour by agitation.

The air found to have ariſen from it was carbonic acid gas, that had been formed from the carbon of the blood and the oxygen of the vital air. This blood on expoſure to hydrogen gas, loſt in a few days it's natural colour and brilliancy, and was brown; a few days afterwards it appeared to have ſeparated into ſeveral parts by undergoing a decompoſition, it had an oily aſpect, and it's colour was purple reſembling wine leys. Theſe changes are attributed by this chemiſt to the abſorption or diſengagement of oxygen.

Exſiccated blood being put into a crucible and heated by degrees, it became at firſt ſoftened and conſiderably puffed up; there was then extricated a great quantity of very fetid greeniſh yellow fumes, this was ſucceeded by inflammation, and the flame was white and manifeſtly oily. After the oil and ammonia had been formed and diſengaged, there was a formation of pruſſic acid gas, eaſily known by it's odour reſembling peach flowers, and it's property of precipitating iron blue. In about ſix hours the matter was conſumed to four-fifths; it became ſoftened a ſecond time, from the ſaline and fixed matters it contained; and there aroſe upon it's ſurface a purple flame, accompanied with a very thick ſmoke that very ſtrongly irritated the eyes and noſe: this was phoſphorus in a ſtate of combuſtion, which had been formed by the action of the carbon on the phoſphoric acid. The reſiduum afforded no ſoda, which blood is known to contain, it having been volatilized by the exceſſive heat: but muriat of ſoda was found, and the oxyd of iron in part reduced, as it was attracted by the magnet; it reſembled that from the Iſland of Elba. Exſiccated blood diſtilled in a retort, to which a pneumatic apparatus was attached, afforded at firſt a clear liquid, like water, then carbonic acid gas, and carbonat of ammonia, which appeared on the ſides of the glaſs in the form of beautiful cryſtals; theſe were ſucceeded by a fluid oil, hydrogen gas, and an oily ſubſtance of the conſiſtence of butter.

Beſides the exact manner in which this chemiſt had decompoſed blood by heat and collected it's products, whether in a fluid, fixed, or aerial and gaſeous form, he made a very important diſcovery of the preſence of the bile in it, which he aſſures us was the caſe. He firſt coagulated ſome blood by boiling it in diſtilled water, and the filtered liquor was of a green colour and odour perfectly analogous to thoſe of bile; when evaporated to the conſiſtence of honey, it's bilious odour became very ſtrong, and it's green colour much deeper. On diſſolving this extract again in water, it gave it a greeniſh colour and the property of frothing very much on agitation. This ſolution was precipitated by acids and alcohol; the precipitate formed by the laſt was gelatin, being ſoluble in cold water. The precipitation by acids was a real decompoſition ſimilar to that of bile when treated by theſe reagents. Hence this product of the blood procured by a ſimple proceſs had all the characters of the bile of the ox, viz. it's odour, colour, bitter nauſeous ſavour, and it's manner of being acted upon by reagents. The diſcovery of this ſubſtance confirms one of the ideas of the ancients on the compoſition of the blood. Bile.

It is to the examination of the ſerous part of the blood Serum.

to which we are indebted for the diſcovery that Fourcroy made of the *gelatin* exiſting in this fluid, where Rouelle and the other chemiſts had only found albumen, alkali, and neutral ſalts. The exiſtence of jelly in the blood, according to the writings of the ancients, was out of all doubt; but from the properties they attributed to it, it appears they confounded it with the lymphatic matter, which in ſome circumſtances has really the ſame properties. De Haen was ſo convinced of jelly in the blood, that he could not conceive how this fluid could be without it, but it was neceſſary to give a demonſtration of it, and Fourcroy engaged in it.

He found the ſpecific gravity of ſerum to be eight times greater than water, that it is eaſily diſſolved by water from zero to the temperature of 50 and 55, at which degree it coagulates. It was alſo coagulated by acids and alcohol, and heat was diſengaged at the time. Serum put into a glaſs veſſel of the thickneſs of one line, and plunged into a bath of diſtilled water, coagulated at 60° of Reaumur, the barometer being at 28 inches. When coagulated it was of a light grey colonr, it's conſiſtence and odour very ſimilar to the boiled white of an egg, and had in ſome meaſure it's ſavour. During the coagulation a liquor ſeparates which is ſlightly turbid, this is *gelatin*; on evaporation, it becomes a trembling maſs. In the blood this liquor is always clear, but in the ſerum always ſomewhat opake.

Serum when diluted with ſix parts of diſtilled water was not coagulated by the boiling heat, or by evaporation, to a greater than natural conſiſtence; but a pretty firm tranſparent pellicle appeared on it's ſurface reſembling that on heated milk, ſo well deſcribed by Parmentier and Deyeux. Darcet and Scheele likewiſe knew that the addition of a certain quantity of water prevented the coagulation of ſerum by heat. Mixed with half or even with twice it's weight of water, it coagulates, and on evaporation carbonat of ſoda and marine ſalt are obtained; theſe ſalts it appears are but ſlightly embarraſſed by the portion of gelatin and albumen that remain diſſolved in this water, and when the liquor is ſtrongly evaporated, they ſeparate on cooling.

The circumſtance that appeared to Fourcroy the moſt worthy of being recorded, was his being able to diſcover the cauſe of the coagulation of the albuminous matter by heat. Having obſerved that the white of the egg became thick in proceſs of time by contact with the air; that an egg that had been kept a long time, ſo as to be able to have abſorbed the air, was much ſooner boiled or hardened than a freſh egg; and that the laſt never became ſo hard as an old egg; he concluded that the fixation of oxygen was the cauſe of this coagulation, and that a certain degree of heat was neceſſary to unite the albumen with the oxygen, the ſame asit is neceſſary in the combuſtion of all combuſtible matters, in the oxydation of metals, &c. It was in this manner that the thickening of the lymphatic liquids in the air, the formation of the white, thick, homogenous and concreſcible pus in open wounds, and in ulcers of the lungs which admit the air, had been explained; but a direct experiment was required to remove all objections. Several drachms of ſerum were therefore mixed with an oxyd of quickſilver that had been precipitated by potaſh from the oxygenated muriat of mercury; and it was found that in about 12 hours the oxyd had loſt it's redneſs and was become black or grey, which announced a ſeparation of the oxygen and a reduction of the oxyd, whilſt in proportion as this took place, the ſerum was found to thicken, it was even very hard on it's ſurface, and by agitation the whole became perfectly concrete and ſolid.

Having thus accounted for the coagulation of the albumen, the curioſity of this chemiſt was next directed to compare the blood of the human fœtus with that of the adult. He remarked that the blood which had been drawn a few hours from the umbilical cord of a newly born infant was coagulated. The ſerous part, which was very abundant had a red colour tinged with brown; it ſenſibly changed paper ſtained with mallows to a green colour; it coagulated at a heat of 55° of Reaumur, the barometer being at 27 inches 8 and $\frac{6}{10}$ lin.; but it was not ſo ſolid as that of the blood of the ox, and a great part of the ſerum remained uncoagulated. It was not white when coagulated, but being combined with a certain proportion of colouring matter, this coagulum had a browniſh grey colour. The filtered liquor from this coagulated ſerum, diluted with diſtilled water, was not ſenſibly troubled by lime water, hence Fourcroy concludes that the ſerum of the fœtus contains no phoſphoric acid.

The coagulum was not ſo ſolid as that of the adult, it was of a deep brown red colour, hence it does not become ſo completely red as that of thoſe who have reſpired; there only appeared to be ſome red threads which variegated the ſurface of the brown maſs, ſo that it ſeemed to be veined with a purple red on a ground of a dark brown. This coagulum well waſhed with diſtilled water did not afford $\frac{1}{2}$ of fibrous matter. The waſh expoſed to heat coagulated, and the filtered liquor after having been evaporated to 14 ſhowed no ſigns of the preſence of phoſphoric acid. From theſe experiments the blood of the human fœtus differs from that of the adult in three remarkable properties: 1ſt. It's colouring matter has a deeper ſhade, and is not ſuſceptible of receiving the ſplendid purple by the contact of the atmoſpheric air; 2d. It contains no fibrous matter concreſcible on cooling, the thick and coagulated portion inſtead of it ſeems rather to approach to the gelatinous matter; 3d. It contains no phoſphoric acid. It appears to this chemiſt, that the firſt two characters, ſo different from thoſe obſerved in the blood of young people and of adults, manifeſtly ariſe from the fœtus not having reſpired, the contact with the atmoſpheric air not having yet modified the nature of this fluid by the caloric it affords, and by the carbon it abſorbs from it during the act of reſpiration. The great difficulty of procuring this blood in ſufficient quantity prevented this chemiſt from purſuing the comparative experiments he deſired, which are neceſſary to render it's analyſis more exact. To this account of the inveſtigation of the blood may be added the curious fact of this chemiſt having found real native pruſſian blue in the blood of a ſick perſon, which on expoſure to the air aſſumed the brighteſt blue colour.

Pruſſian blue in the blood.

Parmentier and Deyeux.

Having deſcribed the principal part of the labours of the ancients and moderns on the analyſis of the blood, to the time that Fourcroy placed the nature of this fluid in a new light, we proceed to give the details of the experiments of two of his ſucceſſors, Parmentier and Deyeux, whoſe combined diligence and talents have enriched the ſubject with the moſt intereſting facts and obſervations.

Parmentier and Deyeux commencing their inveſtigation of the blood as it comes from the veſſels, obſerved, that it differs very little at that time from what it is in the living animal, but it ſoon changes it's ſtate, and the firſt alteration is manifeſted by the loſs of it's fluidity, it's heat, it's odour, and it's homogeneity.

Firſt changes.

Aroma.

They obſerved that whatever is ſuſceptible of altering the nature and properties of the blood has a ſingular influence on it's aroma or odour. To this may be attributed the more or leſs lively impreſſion a perſon receives from this fluid as it flows from the veſſels, or on entering a butchery, the floor of which is wet with the blood of a newly killed animal. This odour is ſometimes ſo ſtrong as ſcarcely to be ſupported, at leaſt by ſome people, inducing a diſpoſition to ſyncope or an inclination to vomit.

Properties of it.

This aroma or odorous principle of the blood had fixed the attention of the chemiſts, but the only circumſtances known of it were, that it is ſoluble in water, and that the fluid which holds it in ſolution changes, and in a ſhort time contracts a putrid odour. Preſuming that theſe were not it's only properties, theſe two chemiſts endeavoured to inveſtigate it further; and they conclude from their experiments that there is no ſpirituous or inflamflammable principle connected with the odorous part, as ſome authors have pretended; but that the deleterious quality which has been experienced upon reſpiring it in large quantity is of a peculiar nature, and eſſentially different from that produced by mofet and carbonic acid gas; and that the means made uſe of to detect the preſence of theſe laſt are inſufficient, to eſtabliſh the properties of the gas that eſcapes from the blood. On examining it's nature, they found the affinity of the odorous principle with the atmoſphere to be inferior to that which it has for water, and that the laſt ſeized it with great avidity. They look upon it to be a compound body ſuſceptible of change, that it's alteration is more ſudden when aſſiſted by a warm temperature, and that it is at the moment this change takes place that the diſagreeable odour is perceived, which is not to be confounded with that which exhales from animal matter the putrefaction of which is complete, becauſe the laſt contains ammonia.

In union with atmoſpheric air.

With water.

Having examined this odorous principle in combination with the atmoſpheric air, they tried it when in ſolution in water. To procure it in this ſtate, they diſtilled ſome venous blood newly drawn from the ox, on a water bath, and they obtained in the receiver a tranſparent colourleſs fluid, of an odour ſimilar to what the blood exhales, and having a diſagreeable nauſeous ſavour. This newly diſtilled fluid was not affected by the ordinary reagents. Evaporated on the water bath it left no reſiduum, and on being kept for ſome time in a well cloſed bottle it became putrid, and lightly changed the ſyrup of violets green. This odorous water loſt it's odour likewiſe at a degree of heat capable of making it ſimmer.

With alcohol.

It is likewiſe ſoluble in alcohol, but the odour of this liquor is not at firſt very marked, it becomes however very evident on diluting it with water. Reagents have no effect upon it.

Analogous to the ſpiritus rector of plants.

With other animal ſubſtances.

Theſe chemiſts, from the above experiments, are of opinion that this odorous principle of the blood is analogous to the *eſprit recteur* of plants, ſince both of them affect very ſenſibly the organ of ſmell, are volatile, are ſoluble in water and in alcohol, and their ſolution is not ſenſibly acted upon by reagents. The moſt remarkable and peculiar property of this odorous principle, is being ſubject to a quick decompoſition, in which ſtate it exhales a diſagreeable and ſometimes a putrid ſmell. They conclude however by obſerving that there is a complete analogy between it and other animal ſubſtances, ſince milk, bile, muſcle, the Urine, &c. have each an odorous principle which ſerves to diſtinguiſh them, and the properties of which reſemble thoſe of the odorous principle of the blood. It is in this aroma that the firſt alteration of animal ſubſtances takes place, to prove which it is only neceſſary to obſerve what paſſes in the air and water which contain this principle in ſolution.

No bile in the blood.

On repeating the experiments of Fourcroy, theſe chemiſts found in contradiction to the aſſertion of that chemiſt, that blood in a healthy ſtate contains no bile, either in it's ſerum or coagulum. They allow, however, that it may perhaps be preſent ſometimes in diſeaſed blood, ſince it appears from ſome phyſicians, that the mucous and milky humours are known ſuddenly to quit their organs to overwhelm the maſs of blood; at the ſame time the numerous contradictions to be met with in books which treat of animal analyſis, often ariſe from the experiments having been made on the ſubſtances in very different ſtates, which they are known to undergo; an inſtance of which is in the urine, for in cold weather the firſt alteration in it is that of aceſcency, whilſt in hot weather it is ſcarcely or not at all obſerved from the alcaleſcency that ſucceeds it. This ſhows how neceſſary it is, in order to obtain ſimilar products from ſimilar experiments, to have the ſubſtances upon which they are to be made always in the ſame ſtate and under the ſame circumſtances.

Serum. Many phyſicians have endeavoured to determine by different experiments the quantity of ſerum contained in the blood. Some have pretended that it's quantity is nearly equal to half of the whole maſs that comes from the veins of a healthy ſubject; others have affirmed that it forms only three quarters at moſt. From the experiments of Parmentier and Deyeux it appears, that the great difficulty of aſcertaining this fact, as well as procuring ſerum in a ſtate proper for chemical analyſis, ariſes from the great variations it admits, in it's coheſion with the coagulum. To obtain this ſerum pure, *i. e.* with the colour that naturally belongs to it, it is neceſſary that the veſſel which contains the blood be ſet in a place of repoſe, at leaſt during an hour, as the ſlighteſt motion is able to affect and oppoſe the ſeparation of this part. On repeated examination of the ſerum, theſe chemiſts found that it contained (as their predeceſſors had proved before them) water, albumen, gelatin, neutral ſalts, and mineral alkali or ſoda. But it remained to determine, whether theſe ſubſtances are in a combined ſtate, or exiſt ſeparately, each of them enjoying their reſpective properties. This queſtion was the more intereſting to determine, as

Rouelle, the only chemiſt that had been any ways ſucceſsful, ſeems to have increaſed the incertitude of it by concluding, that the ſalts, and eſpecially the alkali, were not combined with the other conſtituent parts of the blood. Theſe chemiſts find it difficult to conceive how Rouelle could make ſuch a concluſion, ſince it is unreaſonable to ſuppoſe, that the fixed alkali in the ſerum, together with the gelatin and albumen, can remain by the ſide of theſe two ſubſtances and circulate with them, when experience proves that fixed alkali when mixed with them increaſes their ſolubility.

As a proof of this, if ſome dephlegmated ſpirit of wine be added to freſh ſerum, the mixture will become immediately turbid, and the albumen ſeparated. If very pure alkali be poured on this albumen, it will be diſſolved, and the water with which it ſhall be mixed, will be tranſparent.

To this it may be objected, that the proof of the fixed alkali not being combined with the albumen is, the ſerum changing the ſyrup of violets to a green, a phenomenon which ought not to take place, if the pretended combination exiſted. But it may be anſwered, that there is a combination of the albumen and gelatin with the fixed alkali, in the ſame manner as there is between oils and the alkali; and it is well known that the moſt perfect ſoap has the property of changing the ſyrup of violets green, and nobody certainly can doubt, but that the fixed alkali in the ſoap is combined with the oil.

It may perhaps be ſtill objected, that any analogy between the pretended combination of the albumen in the one caſe, and the ſoap in the other, is ſo much leſs founded, as this laſt matter ſoluble in water is infinitely more ſo in ſpirit of wine, whilſt the ſolution of the albumen by the fixed alkali is not ſoluble in ſpirit of wine, this fluid decompoſing it. To this objection theſe chemiſts look upon the anſwer to be very eaſy. In eſtabliſhing an analogy between the combination of oil and alkali forming the ſoap, and the combination of the fixed alkali with the albumen, ſuch as they ſuppoſe it to exiſt in the ſerum, they are far from pretending that theſe two orders of combinations ought to have a perfect reſemblance; for it is well known, that in order for the analogy between two bodies compared together to be complete, it is neceſſary, that the parts employed in their formation be abſolutely the ſame; without this condition there will be always a ſenſible difference, which however, in other reſpects, will not prevent the exiſtence of an evident analogy. Thus for example, if it be ſaid that the muriatic acid forms a ſalt with fixed alkali, and that this ſame acid likewiſe forms a ſalt with calcareous earth; it is not to be ſuppoſed, that a perfect analogy is intended to be eſtabliſhed between theſe two ſalts, ſince one of them is always deliqueſcent, while the other eaſily takes a concrete form: but it is not leſs true that there exiſts a ſimilitude in the manner in which this acid combines with the alkali and the calcareous earth; hence in this reſpect there is an analogy between the two ſalts. It is the ſame reſpecting the combination of the albumen with the alkali, ſome of the properties of which differ from thoſe of the ſoap only by the conſtituent parts of theſe two bodies not being perfectly alike. It therefore appears to be proved, that the fixed alkali found in the ſerum is in a ſtate of combination with the albumen, and that it does not circulate in the blood in a free and iſolated ſtate.

Fixed alkali combined with the albumen.

This, however, cannot be ſuppoſed to be the caſe with the muriats of ſoda and of potaſh that exiſt in this fluid. Theſe ſalts, that have no tendency to combine like the alkali, may be looked upon to be in a diſengaged ſtate in the ſerum, hence it is only with reſpect to theſe that the opinion of Rouelle ought to be adopted.

The muriats of ſoda and of potaſh are in a diſengaged ſtate.

Sulphur. From the very ſtrict examination which theſe chemiſts made of this albumen, they found that independent of the fixed alkali combined with it, it likewiſe contains ſulphur, and this diſcovery is one of the moſt curious and important that has yet been made in the analyſis of the blood.

How obtained. To ſhow the preſence of ſulphur, the albumen muſt be heated in a ſilver veſſel, and being perfectly dry, be made to undergo a degree of heat greater than that of boiling water, when the part of the veſſel in contact with the matter will ſoon be ſeen to loſe it's metallic ſplendour, and become of a black colour, reſembling that which ſulphur produces when heated upon a ſilver plate. This ſulphur may be obtained apart. For this purpoſe, ſome of the albumen is to be triturated in a glaſs mortar, with a few drops of a well ſaturated ſolution of ſilver; on digeſting this mixture a certain time, then heating it after diluting it with water, ſome greyiſh threads will be obſerved, which, by degrees, will become black, and will form at the inferior part of the veſſel a precipitate, from which it will be eaſy to extract the ſulphur in the ordinary way. In ſhort, if fixed alkali be boiled with albumen and water, a liquor will be obtained, which being filtered and mixed with diſtilled vinegar, exhales an hepatic odour, ſuſceptible of changing the colour and ſplendour of ſilver.

With reſpect to the preſence of this ſulphur in the ſerum, and it's origin, different queſtions may occur. Is it the product of animalization, or rather according to theſe chemiſts, muſt it not be attributed to the decompoſition of a body which contained it already formed? Without engaging in any diſcuſſion that might lead from the principal object, it is only neceſſary to obſerve, that the albumen of the blood is far from being the only animal matter in which ſulphur is to be obtained, ſince it has been extracted from the white of the egg; it is ſuſpected to exiſt in bile, and it is preſent in great abundance in the ſubſtance of the brain. It appears to theſe chemiſts very probable, that the ſulphur which is found in the greater part of the animal fluids is as eſſential to them as their neutral ſalts, and ſince it is conſtantly found in them as well as in ſerum, it ought to be regarded as one of their conſtituent parts.

Gelatin.

Of all the parts of the ſerum, the gelatin which it contains more particularly engaged the attention of theſe two chemiſts. It has been before obſerved, that Fourcroy had made it the object of his examination, but the experiments of this learned chemiſt being repeated, and only affording inſufficient reſults, new experiments were neceſſary to procure it in it's perfect ſtate, which was effected in the following manner:—About ten ounces of very pure ſerum were expoſed to the heat of the water-bath in a glaſs baſon, and inſtead of withdrawing the veſſel immediately after coagulation of the lymphatic part, as is the cuſtom, it was permitted to remain for half an hour longer. On examining the matter, it was of a white colour, and the different parts that touched the internal ſides of the veſſel were ſtrewed with ſmall cells that contained a yellowiſh matter. On the ſurface of the coagulated lymph was a thick, yellow, tranſparent ſubſtance, having all the appearance of a jelly; half an ounce of this being ſeparated, and ſubmitted to different experiments, preſented the following properties.

Method of obtaining it.

It produced the ſame effects as glue when taken between the fingers, or extended upon paper; it was of a mild ſavour, was readily diſſolved either by the ſaliva or by water; the laſt ſolution on being expoſed to a humid and warm air, ſoon became covered with a mouldineſs; in this ſtate it had a ſomewhat acid ſavour, and in time it became putrid. Another portion of this matter, expoſed in a warm place, became dry, and formed on the plate of glaſs, where it was extended, a tranſparent layer, as yellow as amber, which on being afterwards diſtilled on a naked fire, afforded the ſame products as the jelly of hartſhorn. When mixed with cauſtic ſoda, diluted with water, it was ſoon diſſolved, the ſolution was clear and tranſparent, but on attempting to ſeparate it, inſtead of reappearing in the gelatinous ſtate, it was only in the form of white flocks. Having repeated theſe experiments on the ſerum of the blood of many animals, theſe chemiſts were convinced of the exiſtence of gelatin in the blood, and that it forms an eſſential conſtituent part of this fluid.

Part of it in a combined ſtate.

They likewiſe obſerve, that the gelatin ſeparated in the above experiment is not the only part that exiſts in the blood. They think it more than probable, that another portion is combined with the cauſtic ſoda found in this fluid, by which combination it loſes it's peculiar property of appearing in the form of jelly, and which accounts for it's not reappearing with this property in the ſeroſity where it is thus diſſolved. The gelatin therefore, which is manifeſt on the ſubſtance of the ſurface of the coagulated albumen is only that, which not having found a ſufficient quantity of ſoda in order to be diſſolved, naturally takes the thick conſiſtence which belongs to it when it is not combined with a foreign body. This mode of reaſoning is ſupported by the phenomenon obſerved on the addition of ſome cauſtic ſoda, that had been added to ſome ſerum: for on heating the mixture, gelatin was no longer obtained, one part of the albumen was alſo diſſolved, and the coagulum, inſtead of being ſolid, only became of a ſoft and pultaceous conſiſtence.

It now remains to know, if the ſoda, the albumen, and gelatin, are in an iſolated ſtate, and circulate ſo in the blood without being combined; or rather if the combination of one part of theſe ſubſtances only takes place when the ſerum is coagulated by heat, a circumſtance difficult to determine.

Having already proved the exiſtence of gelatin in the ſeroſity, the next thing was to find out if the coagulum, as well as the fibrous matter ſeparately examined, would equally afford gelatin.

The analogy of the fibrous matter with the muſcular ſubſtance, gave them reaſon at firſt to ſuppoſe that gelatin would be found in it. For this purpoſe, one pound of fibrous matter was ſeparated from the blood of a freſh killed animal by agitation, and boiled for about half an hour in diſtilled water. The liquor was then evaporated on the water bath even to three fourths: on cooling, it afforded no jelly, and expoſed afterwards to the air in a warm place, it continued to evaporate without ſhowing any gelatinous matter.

They were not more fortunate in their examination of the coagulum, from which the ſerum had been ſeparated as much as poſſible.

Gelatin only in the ſerum.

From theſe experiments, it would appear that the ſerum is the only part of the blood that contains gelatin, and that it is in vain to look for it in any other of the component parts.

Differs in different blood.

It was likewiſe diſcovered, that the gelatin is not conſtantly the ſame in the blood of all animals; in the blood of healthy people it is found to differ both in conſiſtence, colour, and quantity; and equal differences are obſerved in the gelatin of the blood of diſeaſed people. From the firſt obſervations which Parmentier and Deyeux made on this ſubject, they were in hopes of finding, that the ſtate of the gelatin might be a means of diſcovering the nature of the diſeaſe: but experience ſoon taught, that they were deceived; for in people labouring under the ſame diſeaſe, ſome afforded blood the gelatin of which had a great deal of conſiſtence and was in large quantity; others blood of which the gelatin was much ſofter and in leſs quantity. In ſhort, it would ſeem, that it is with the gelatin as with the fibrin and albumen, which are never identic in all individuals; that their peculiar ſtate, their nature, and their quantity, depend on numberleſs circumſtances relating to organization, which it is impoſſible for the chemiſt either to appreciate or indicate.

From the preceding experiments, the opinion of Fourcroy on the exiſtence of gelatin in the ſerum of the blood has therefore been confirmed by theſe chemiſts, and there is reaſon to believe that this diſcovery may be a means of conducting the phyſiologiſt to the true theory of the formation of the muſcular fibre.

Coagulation of blood.

Blood that is freſh drawn from the vein has it's ſurface commonly covered with a froth, a great part of which is diſſipated as ſoon as formed. The blood inſenſibly loſes in volume, and a thick ſubſtance is ſeen to form around the ſides of the veſſel that contains it, which proceeds to the centre; this conſiſtence increaſes until the whole is in a ſtate ſimilar to a jelly. When the coagulum is ſeparated from the ſerum in which it ſwims, it is tender and eaſily divided; internally examined, it preſents a lamellated form, which appears to indicate a ſymmetric arrangement; the external part of the coagulum is of a lively red, whilſt thoſe parts of it not expoſed are dark coloured.

Various opinions of it's cauſes.

The cauſe of the coagulation of the blood, when it is drawn from the veſſels, the circumſtances that attend, that accelerate, retard and ſuſpend, or deſtroy this coagulation, have given riſe to many diſputes. It had been attributed to the cold the blood meets with out of the body, but Hewſon proved that this was an erroneous opinion, and the ſame has been confirmed by Parmentier and Deyeux; for having received ſome blood in two bottles; one was plunged in water heated to 50°, the ſecond in water at zero, and the third expoſed to an atmoſphere at 15°; but the coagulum was formed at the ſame time, and in the ſame manner, in all the bottles.

According to Hunter, the coagulation of the blood takes place, although it be preſerved at a degree of heat equal to that of the animal: that it goes on in the open air, in vacuo, or in a cloſed veſſel. Neither repoſe nor agitation prevents it; and this coagulum abounds in the veſſels neareſt to a gangrenous part. During it's coagulation the blood does not increaſe in temperature, whilſt all other bodies do in paſſing from a fluid to a ſolid ſtate, but reſiſts congelation longer than other bodies, and more ſo the firſt time than afterwards. This phiſiologiſt looks upon the coagulation of the blood to be analogous to the tonic contraction of the muſcles which takes place after death, whilſt the cauſes that deprive the muſcles of this tonic force likewiſe deprive the blood of the power of coagulating. Theſe cauſes are the abſence or preſence of the vital principle.

Not occaſioned by air,

Some have pretended that the air occaſioned the tendency to coagulation, and that if the blood be kept in a veſſel hermetically ſealed, the coagulation does not take place. To verify this aſſertion, Parmentier and Deyeux received ſome blood both from the veins and arteries of an animal into three ſmall glaſs bottles of the ſame ſize; one was cloſed with a ground glaſs ſtopple, the ſecond with cork, and the third was left open; but in all three bottles the coagulation was found to take place in the ſame manner, and at the ſame time.

or by neutral ſalts.

Neutral ſalts, when mixed with blood, oppoſe it's coagulation. This was previouſly ſhown by Hewſon; but ſuſpecting that this effect might be owing to the agitation which he recommends to give the mixture in order to favour the ſolution of the ſalts, about ſix ounces of blood were received in two flaſks, the one of which contained a ſolution of half an ounce of ſulphat of ſoda, and the other, a ſolution of the ſame quantity of muriat of ſoda; and the effect was, that the mixtures preſerved their fluidity, and there was no coagulum to be obſerved.

In order to find out if it was not the denſity of the fluid, rather than the action of the different ſaline matters, that prevented the approaching of the fibrous part, and conſequently the formation of the coagulum; ſome blood was received in two veſſels, one of which contained a ſolution of gum arabic, and the other a ſolution of ſtarch, but the coagulation took place in both veſſels, whether the liquids were hot or cold. Hence it appears, that this coagulation which the blood undergoes is independant of the action of air, heat, cold, or the denſity of the liquor.

The coagulum.

The coagulum, or clot, preſerves it's conſiſtence and odour for three, four, or five days, eſpecially when the veſſel that contains it expoſes but a ſmall ſurface, and is placed in a freſh place; in a warm temperature, or the contrary, it ſoon becomes ſofter, ſuddenly loſes it's conſiſtence, it's colour begins to change, and at laſt it is extremely fœtid.

Expoſed to heat.

If inſtead of letting the coagulum remain in the ſerum, it is ſeparated from it, and placed in a warm ſituation, it becomes dry without ſuffering any change; in this caſe, it's colour is of a very deep red, and towards the edges it acquires a ſemitranſparency. If the coagulum ſeparated from the ſerum be left to drain for the ſpace of half an hour, and be afterwards expoſed to the heat of a water-bath, it becomes of a more ſolid conſiſtence, and the liquor which drops from it is in all it's properties the ſame as the ſerum. If the coagulum be put into a certain quantity of boiling water, it gives this fluid a milky hue; there likewiſe ariſes at the ſame time to the ſurface a ſcum, which is owing to a portion of diſſolved albumen; the coagulum is then of a brown colour and more ſolid.

Alcohol. If the coagulum be digeſted in ſpirit of wine it likewiſe increaſes in conſiſtence; but the ſerum which ſeparates contains no more albumen. On leaving the alcohol to remain on the clot, it only acquires a lemon colour, provided it has been perfectly dephlegmated, and it's mixture with water does not change it's tranſparency.

Water. This is not the caſe with water; this fluid divides the coagulum, becomes red, and remains tranſparent for many days; but it inſenſibly becomes turbid, and there ariſe ſome *membranous pellicles.*

Acids. Acids have more or leſs action upon the coagulum; they all, however, increaſe it's ſolidity by coagulating the albumen which is ſtill contained in the ſerum. To this the nitrous acid is an exception, for it appears to bring about it's diſſolution, whilſt the phoſphoric and ſulphuric acids change it to a black. When the coagulum has been expoſed to the action of the acids, it is no longer ſoluble in water as before, it is only divided by it, by which it's tranſparency is affected.

Alkalis. The carbonats of potaſh and ammonia diſſolve the coagulum. When theſe alkalis are in their pure ſtate (deprived of their carbonic acid) they give it a deep red colour. This ſpecies of ſolution may be preſerved ſome time without becoming putrid or undergoing any change. There is no appearance of thoſe *membranous pellicles*, above-mentioned, ſince it appears, that the alkali, on combining with them, has given them a ſpecies of ſolubility.

Diſtilled. If the coagulum be diſtilled in a retort, it affords the ſame products as other animal ſubſtances, and the carbon which remains, contains iron, ſoda, &c.

Fibrin.

On giving an account of the property which water has of diſſolving the coagulum, it was obſerved, that there always remains behind a *membranous matter* on which this fluid has no action. This is eaſily ſeparated by a very ſimple method; it is only neceſſary to encloſe the coagulum in a piece of linen, and to rub it between the hands at different times, in a veſſel filled with water, when the ſoluble part will ſeparate by degrees and leave a reſiduum, which is the real fibrous matter of the blood, and which ſo many authors have confounded with the coagulable lymph. It is in large quantity. It is moſt probable that this fibrin exiſts in the coagulum of the blood in a ſtate of extreme diviſion, and that it only takes the form obſerved, on uſing the proceſs already deſcribed; that is, by the motion imprinted on the coagulum by agitating it in water. This idea appears to be ſupported by what is obſerved on agitating the blood juſt drawn from the vein, when the fibrous matter ſeparates in large quantity, and adheres to the hands or the inſtrument made uſe of to agitate this fluid.

The manner of extracting the fibrin, in the above experiment, appears to Parmentier and Deyeux to be of uſe in explaining the manner in which it ſeparates ſpontaneouſly in the living body. According to the greater part of phyſiologiſts, this matter is deſtined for the purpoſe of forming and repairing the ſubſtance of the muſcles; if this be the caſe, it may be ſuppoſed, that the blood, by being in a conſtant motion during it's circulation, tends by ſuch agitation to deprive itſelf each moment of it's fibrous matter, and to depoſit it in greater or leſs quantity, and more or leſs ſuddenly according as it's motion is more rapid; whether this be the caſe or not, it is certain, that the fibrin is found entire in the fleſhy part of the body, and that when it is ſeparated from it, it is not ſenſibly different from that which the blood affords that has been agitated on coming from a vein.

Explanation of the coagulation.

It appears, that the influence of this fibrous matter on the formation of the coagulum, or coagulation of the blood, has not been ſufficiently attended to by authors. Theſe chemiſts, however, are of opinion, that the property of the blood to remain fluid, when this matter has been ſeparated from it by agitation or motion, ſhould naturally incline a perſon to an opinion that it contributed to bring about the concretion of the ſubſtance that conſtitutes the coagulum; and the cauſe that produces this phenomenon they attempt to explain in the following manner, and which appears to be taken from the explanation previouſly given of it by Hunter, or greatly reſembling it. Whilſt the blood remains fluid and homogeneous, it may be conſidered as being ſtill endued with life or vital motion. The fibrous part it contains, and which is found diſſeminated through it's whole maſs, enjoys a ſort of irritability; but in proportion to the diſtance of time the blood which contains it has been drawn from the veſſels, it loſes it's motion, in ſhort, it happens at the inſtant the vital principle entirely leaves it, and it may be conſidered as in a ſtate of death, that ſtill preſerving, during ſome ſeconds, the motion of the palpitation of the expiring fleſh, it contracts, unites with a part of the matter near it, and retains and communicates to it this ſtate of trembling jelly, the external properties of which have always impoſed upon the cauſe of the real formation of it.

Theſe chemiſts at firſt agreed with what ſeveral ancient and modern authors had ſuppoſed, thar the coagulation of the blood out of the veſſels was owing to the ceſſation of the natural heat; and they were willing to adopt this opinion from obſerving, that it is principally when this fluid is entirely cool, that the whole maſs of blood is in the form of a coagulum, and in certain reſpects to be compared with the jellies of fruits; but the reflection of Hewſon, and further experience, particularly from their frequenting the butchers, changed their opinion, and afforded them no doubt but that the blood in it's ſeparation and coagulation follows none of the laws attending on cold; but that repoſe and motion are the two great means of operating or preventing this decompoſition.

Not affected by cold.

But by repoſe and motion.

This is ſupported by the obſervations of Hewſon, who, on examining the blood as it flowed at different times, found, that the blood which came immediately after the opening of the vein required more time to coagulate than that which he received later. The ſame was alſo verified by theſe chemiſts, who, on attending the butchers, obſerved, that the blood that firſt ſpouted from the veſſels of a beaſt was very fluid, but in proportion as theſe veſſels loſe their ſpring, and the organic action weakens and life eſcapes, the blood acquires more conſiſtence, and flows nearly coagulated or nearly dead when the animal expires: that whatever be the temperature, the coagulation takes place at the ſame time, if the motion and action of ſalts do not interfere immediately to deſtroy the vital irritability of the fibrous matter, and kill it; if this laſt be the caſe, the blood is only in the form of a liquid, which no means yet known can recal to a ſtate of coagulation. In thoſe animals whoſe blood contains a very large proportion of fibrous matter, it's concretion is made in a very regular and uniform manner; as is the caſe with the blood of the ox, the coagulum of which is only to be divided with nicety in certain directions, and always in the form of lamellæ.

If one or ſeveral of theſe be ſeparated from a clot of this kind, all the ſaline matter may be ſeparated from them by means of ablution in water, whilſt the fibrous matter, deprived of it's colour, remains alone, repreſenting a maſs of very delicate texture. Such are the ideas of theſe two chemiſts on the formation of the coagulum.

Their experiments were alſo repeated on the blood of many domeſtic animals, ſuch as that of the horſe, ſheep, calf, lamb, and pig, and they found, that this fluid afforded the ſame products in all. It appeared, that only the ſtate of theſe products preſented any very ſenſible difference; for example, the blood of the calf and lamb always afforded a fibrous matter, the texture of which was ſoft when compared to the ox and ſheep. The ſerum likewiſe produced an albuminous matter, which underwent no great degree of coagulation by heat. They found, in general, that the ſtate of health, and vigour of animals, had peculiar influence on the albumen; for on examining the blood of diſeaſed perſons, it often happens, on comparing it with that of healthy individuals of the ſame ſpecies, that very marked differences were to be obſerved in this ſubſtance.

Albumen greatly affected by health and diſeaſe.

Colouring matter.

The next object which theſe chemiſts had in view was the examination of the colouring matter. To obtain it, ſome freſh formed coagulum was put into a linen bag, and waſhed in diſtilled water until the fibrous matter was completely ſeparated. On heating the water of ablution by the water bath, there ſoon aroſe a thick matter of a very deep red colour, which ſwam in the fluid that had previouſly held it diſſolved; this being ſeparated by the filter, and ſtrongly expreſſed to deprive it of all it's humidity, had loſt it's continuity, was eaſily cruſhed, and was reduced to a powder; in this ſtate it had neither odour nor ſavour, and being expoſed to a gentle heat, it became of a very decided black colour.

Acids.

The diluted acids had no action upon it, but when concentrated they decompoſed it, and reduced it to a ſpecies of coal, and this is more effectually done by the aſſiſtance of heat.

Fixed and volatile alkalis have very little action on it; but the ſolution inſenſibly takes place when theſe alkalis are in a cauſtic ſtate, and aſſiſted by heat. Alkalis.

Spirit of wine, digeſted on this matter, was not ſenſibly coloured by it. Alcohol.

Vitriolic ether receives a yellow hue from this matter, but ſoon lets it fall down, and only preſerves a ſlight yellowiſh colour, which ſoon leaves it.

The ſame effect takes place when this matter is boiled a moment in fat oil. Oil.

On diſtilling the colouring matter in a retort, it affords products ſimilar to thoſe which the ſerum, fibrous matter, and the whole blood afford when ſubmitted to the ſame proceſs. Diſtilled.

From the above, it appears, that this matter, which has been coagulated by the heat, is only the albumen of the ſerum combined with the colouring part; and it may be readily conceived, that the albuminous matter ought to make part of it's compoſition, ſince it is in the midſt of a fluid filled with albumen that the coagulum is formed, and that this being divided and left to drain, affords a ſerum ſimilar in it's chemical properties to that ſeparated on the formation of the coagulum. To prove this, however, it is neceſſary to iſolate the albumen from the tinging ſubſtance that colours it red; but the experiments which theſe chemiſts made with this view were not ſo ſucceſsful as was expected. Combined with the albumen.

The inſufficiency of chemical means gave reaſon to ſuppoſe at firſt, that the redneſs of the blood was only produced at the inſtant of combination of the body which gave the colour (although not coloured itſelf) with the ſubſtance of the coagulum, in the ſame manner as oxygen when added to lead and mercury in minium and red precipitate. But this idea of the coloration of the blood was ſoon abandoned by the chemiſts; for, on conſulting the opinions of different authors, they found that the opinion which attributed the cauſe to the iron this fluid contained had many partizans, eſpecially ſince it has been proved, that iron introduced into the animal ſyſtem in the form of medicine ſingularly exalted the colour of the blood, and even reſtored it's colour after it had loſt it.

Iron in the blood.

With reſpect to this metal exiſting in the blood, chemiſts have been more occupied in finding it than in determining with preciſion the ſtate in which it exiſts; but it's demonſtration in this fluid is complete, as appears more particularly from the experiments of Rouelle, Menghini, and Galeati, who limited themſelves to one experiment, which proved that fire is abſolutely unneceſſary to detect it's preſence, and that it is ſufficient to mix a little powder of nut galls with the blood for it to become in leſs than 48 hours of a deep black colour. Beſides, if the blood be expoſed to a heat inferior to that of boiling water, the coagulum preſſed and dried in the air gives unequivocal proof to the magnet of the exiſtence of this metal.

It's colour explained by it.

A further examination of the chemical phenomena ariſing from this ſubject has given theſe chemiſts reaſon to think, that they have found the ſolution of the problem of the coloration of the blood, and they explain it in the following manner:

Since iron exiſts in the blood, it muſt be either in the ſtate of a metal, an oxyd, or combined with an acid, and conſequently in a ſaline ſtate; or laſtly, combined with a body which, without being acid, is capable of forming with it an union, which gives it the property of being ſoluble in aqueous fluids: and it was upon theſe grounds that theſe chemiſts directed their reſearches.

Not in metal.c ſtate.

They found that iron exiſts in the blood neither in a matellic ſtate nor as an oxyd; for on diluting ſome blood with water and preſſing the liquor through a filter, or keeping it in a freſh and tranquil place, they found no iron either on the filter or at the bottom of the veſſel, which ought to have been the caſe from the weight of it's particles; and with reſpect to any martial ſalt being in the blood, the ſoda which exiſts in it would prevent it's formation.

But diſſolved by the ſoda.

It was on calling to mind the different properties of fixed alkali, and eſpecially that of being able to diſſolve iron under certain circumſtances, that theſe chemiſts think they have diſcovered it to be the real ſolvent of iron in the blood, and that the ſolution of this metal thus effected is the colouring principle of this fluid. In order to explain the ſolution of iron ſuch as it is found in the blood, they ſhow the manner by which a ſimilar ſolution is effected out of it. If a very ſmall portion of iron at a time be put into ſome diluted nitric acid, a ſolution takes place, and when it is perfectly ſaturated fixed alkali may be mixed with it in exceſs, which immediately communicates to the liquor a very deep blood colour. In this caſe the nitric acid in diſſolving the iron is in great part decompoſed; the metal unites to the oxygen, one of the principles of the acid; and it is only after it is well ſaturated with this, that the portion of acid undecompoſed lays hold of and diſſolves it. The alkali being added takes the oxyd of iron from this acid, and inſtead of precipitating combines with it, and it is preciſely at the moment this combination takes place that the red colour appears.

Which produces the colour.

The liquor therefore contains two different combinations, the one is nitre, and the other a compoſition formed from the union of the fixed alkali with the oxyd of iron, which combination of alkali with the iron gives it ſolubility. Theſe chemiſts ſuppoſe that a ſimilar combination takes place in the blood, but in order to effect it nature has no need of employing the nitric acid as an intermedium; any other acid is ſufficient to have diſſolved the iron, ſuch as the phoſphoric, which many chemiſts have proved to exiſt in the blood; or even without admitting a previous ſolution of the metal in an acid, it is ſufficient that the iron in the blood be properly oxygenated in order that the fixed alkali may be capable of combining with it, and the oxydation of the iron may be conceived, on recollecting the large quantity of oxygen which is introduced into the lungs by means of reſpiration.

As to the quantity of iron in the blood it cannot be doubted, admitting it's ſolution by the fixed alkali, that there is a ſufficiency of it to produce a liquor of a very beautiful red colour. As a proof, however, two ſcruples of iron, the quantity ſuppoſed to have been found in one pound of blood, were diſſolved with ſome fixed alkali, and the ſolution obtained was of a beautiful red, and ſufficiently deep to colour more than one pound of water. The maſs of blood contained in the human body has been valued in different ways, but as it appears from the calculations of many phyſiologiſts that a middle aged healthy perſon requires 25 pounds of blood for exiſtence, it follows from the experiments of Menghini that in ſuch proportion there muſt be 70 ſcruples, or 2 oz. 7 drachms 1 ſcruple of iron. This quantity is certainly very conſiderable, and Menghini is of opinion that ſome future age may ſee nails, ſwords and other inſtruments manufactured from the iron contained in the human blood. If therefore it be added to what is already mentioned, that fixed alkalies and nitre mixed with the blood increaſe it's colour and render it more durable, and that the ſame effect takes place from the ſolution of iron by fixed alkali in the above experiments, it would appear that the opinion of theſe chemiſts on the ſolution of iron in the blood by fixed ulkali, as well as the coloration of this fluid by this ſame ſolution, cannot be looked upon as entirely devoid of probability.

Whatever, however, may be the opinion adopted on the colour of the blood, it is certain that the coagulum is a compoſed body, and that the red colour has no influence on it's formation, whilſt the oxygen acts a great part in this coloration, for when it is in contact with the blood, the red colour always ſenſibly increaſes.

It is undoubtedly to the change the blood undergoes by the action of heat, which contracts it on drying, that the diſappearance of it's red colour and it's becoming of a deep black, are owing. The iron deprived of the alkali that held it in ſolution, and a part of the oxygen which conſtitutes it an oxyd, changes it's ſtate, hence, when ſeparated by the magnet it is of a different colour to what it was when in a ſtate of ſolution.

Dr. Wells of a contrary opinion.

Since the explanation of the red colour of blood given by theſe two chemiſts, Dr. Wells, in an ingenious memoir in the Philoſophical Tranſactions, has made ſome experiments and obſervations on the ſame ſubject. He is of opinion that there is no proof of blood deriving it's colour from iron, and that no other argument has been given in ſupport of it, than that the red matter is found to contain that metal. He aſſerts that there is no neceſſary connection between redneſs and iron, ſince the ſame metal exiſts in many bodies of other colours, and even in various parts of animals without colour, as bones and wool, and he gives the following more direct reaſons for rejecting the opinion of this metal being the cauſe of the red colour.

His reaſons.

1ſt. There is no colour ariſing from a metal, that can be permanently deſtroyed by expoſing it's ſubject, in a cloſe veſſel, to a heat leſs than that of boiling water. But this happens with reſpect to the colour of blood.

2d. If the colour from a metal in any ſubſtance be deſtroyed by an alkali, it may be reſtored by the immediate addition of an acid; and the like will happen from the addition of a proper quantity of alkali, if the colour has been deſtroyed by an acid. The colour of blood, on the contrary, when once deſtroyed, either by an acid or an alkali, can never be brought back.

3d. If iron be the cauſe of the red colour of blood, it muſt exiſt there in a ſaline ſtate, ſince the red matter is ſoluble in water. The ſubſtances, therefore, which detect almoſt the ſmalleſt quantity of iron in ſuch a ſtate, ought likewiſe to demonſtrate it's preſence in blood; but upon adding Pruſſian alkali and an infuſion of galls to a very ſaturate ſolution of the red matter, the ſlighteſt blue precipitate could not be obſerved in the former caſe, or that the mixture had acquired the leaſt blue or purple tint, in the latter caſe.

The change of colour by air and neutral ſalts not produced on it's colouring matter.

Dr. Wells likewiſe made ſome experiments to ſhow that the alteration produced upon the colour of blood, both by common air and the neutral ſalts, is independant of any change effected by them upon it's colouring matter; in making theſe experiments he found the following precautions neceſſary.

Precautions neceſſary in making the experiments

1ſt. That the blood ſhould be newly drawn and the weather cool. For as the ſolution of the red matter is not to be filtered, but muſt become tranſparent by the gradual ſubſiding of whatever may render it turbid, if the blood be old, or the weather warm, it will often aſſume before it be clear a dark and purpliſh hue. When expoſed in this ſtate to the atmoſphere in a broad and ſhallow veſſel, it's colour changes to a bright red, which however is not brighter than the proper colour of the ſolution. The dark purpliſh hue ſeems owing to ſome modification of ſulphur, for the ſolution poſſeſſing it ſmells like hepatic air, particularly when agitated, and tarniſhes ſilver which is held over it. Neutral ſalts produce no change upon this colour.

2d. The neutral ſalts ſhould not be added to the red ſolution, except when perfectly tranſparent, otherwiſe the ſalts will render it more turbid, and the mixture will appear brighter, if ſeen by reflected light.

3d. Laſtly, the red ſolution ought to be poured gently from the veſſel in which it has been made, otherwiſe, as it is a mucilaginous liquor, it is apt to entangle ſmall particles of air, which by acting as opake matter, will for ſome time alter the appearance of the ſolution. With theſe precautions he began his experiments; he infuſed a piece of black craſſamentum of blood in diſtilled water, and immediately covered the veſſel cloſely to prevent any exceſs of air. Having thus obtained a tranſparent ſolution of the red matter nearly free from ſerum and coagulable lymph, he expoſed a quantity of it to the open air, in a ſhallow veſſel, and poured an equal quantity into a ſmall phial, which was then well cloſed. After ſeveral hours the firſt portion was decanted into a veſſel of the ſame ſize and ſhape as that of the ſecond, and having added to it as much diſtilled water as compenſated it's loſs by evaporation, the two were compared together, and were found exactly of the ſame colour. Two other equal quantities of the red ſolution were afterwards poured into two phials of the ſame ſize and ſhape; to one, a little of a ſolution of nitre in water was added, and to the other, as much diſtilled water. On compoſing theſe together their colour was alſo preciſely the ſame. Laſtly, he cut a quantity of dark craſſamentum into thin ſlices, and expoſed them to common air, and when they became fluid, put them into a phial containing diſtilled water. He then took as much of the ſame craſſamentum, which was ſtill black, and infuſed it in an equal quantity of diſtilled water, contained in a phial ſimilar to the former. The two

Experiments.

ſolutions thus obtained, one from fluid, the other from black blood, were however, of preciſely the ſame colour. The ſame reſults were the conſequence of repeated experiments.

Aſſuming, therefore, as proved, that neither common air nor the neutral ſalts (all thoſe which were tried being ſimilar to nitre in this reſpect) change the colour of the red matter of blood, Dr. Wells attempts to explain the manner in which thoſe ſubſtances give, notwithſtanding, to black blood a fluid appearance, which is founded on the theory of Kepler, Zucchius, and Delaval, viz. that the colours of opake bodies do not ariſe from the rays of light which they reflect from their anterior ſurfaces, but from that portion of it, which having penetrated their anterior ſurfaces is reflected by the opake particles which are diffuſed through their ſubſtance.

Explained on the theory of Kepler, &c.

In adapting this theory to the explanation, Dr. Wells firſt ſuppoſes, that all the parts of blood have the ſame reflective power. The conſequence of which will be, that a maſs ſufficiently thick to ſuffocate the whole of the light which enters it, before it can proceed to the poſterior ſurface, and be thence returned through the firſt ſurface, muſt appear black; for the rays which are reflected from the firſt ſurface are without colour, and by hypotheſis, none can be reflected from it's internal parts. In the next place, let there be diſperſed through this black maſs a ſmall number of particles, differing from it in reflective power, and it will immediately appear ſlightly coloured; for ſome of the rays, which have penetrated it's ſurface, will be reflected by thoſe particles, and will come to the eye obſcurely tinged with the colour, which is exhibited by a thin layer of blood, when placed between the eye and the light. Increaſe now by degrees the number of thoſe particles, and in the ſame proportion as they are multiplied, muſt the colour of the maſs become both ſtronger and brighter.

Having thus ſhown that a black maſs may become highly coloured, merely by a conſiderable reflection of light from its internal parts, he thinks, that if he ſhould be able to prove that both common air and the neutral ſalts increaſe the reflection of light from the internal parts of blood, at the ſame time that they brighten it, great progreſs would be made in eſtabliſhing the opinion, that the change of it's appearance occaſioned by them depends upon that circumſtance alone, and the following obſervations he thinks place this point beyond doubt.

Owing to an increaſe of the reflection of light by thoſe agents.

On comparing ſeveral pieces of craſſamentum, which had been reddened by means of common air and the neutral ſalts, with other pieces of the ſame craſſamentum, that were ſtill black or nearly ſo, he found that the reddened pieces manifeſtly reflected more light than the black. One proof of this was, that the minute parts of the former could be much more diſtinctly ſeen than thoſe of the latter. Now this increaſed reflection of light in the reddened pieces could not ariſe from any change in the reflective power of their ſurfaces, for bodies reflect light from their ſurfaces in proportion to their denſity and inflammability, and neither of thoſe qualities, in the reddened pieces, can be ſuppoſed to have been augmented by common air or a ſolution of a neutral ſalt in water. The increaſed reflection muſt, conſequently, have ariſen from ſome change in their internal parts, by means of which much of the light which had formerly been ſuffocated, was now ſent back through their anterior ſurfaces, tinged with the colour of the medium through which it had paſſed.

Proofs.

The preciſe nature of the change of blood by neutral ſalts, Dr Wells thinks is manifeſt by the following experiment. He poured upon a piece of printed card as much ſerum, rendered very turbid with red globules, as barely allowed the words to be legible through it. He then dropped upon the card a little of the aqueous ſolution of nitre, and obſerved, that wherever the ſolution came in contact with the turbid ſerum, a whitiſh cloud was immediately formed. On ſtirring the two fluids together, the mixture became ſo opake that the printed letters could no longer be ſeen. He has not been able hitherto to deviſe any experiment, which ſhows the exact change induced by common air, but thinks it is evident, that air muſt alſo increaſe in ſome way the opacity of blood, ſince it cannot by any other means increaſe the reflection of light from the interior parts of that body.

The ſame theory explains other facts.

This theory explains another fact reſpecting the colour of blood, which might otherwiſe ſeem unaccountable. If a ſmall quantity of a concentrated mineral acid be applied to a piece of dark craſſamentum, the parts touched by it will for an inſtant appear florid; but the ſame acids added to a ſolution of the red matter in water do nothing more than deſtroy it's colour. On examining the craſſamentnm, the cauſe of this difference of effect is diſcovered, for the ſpots upon which the acid was dropped are found covered with whitiſh films. Hence it is evident to Dr. Wells that the acid had occaſioned an increaſe of opacity in the craſſamentum, more quickly than it had deſtroyed it's colour; and that the red matter, from having been in conſequence ſeen by a greater quantity of light, had in that ſhort interval appeared more fluid than formerly.

Converſion of cinnabar into vermiſion.

The change which takes place in blood, when it's colour is brightened by common air and the neutral ſalts, is ſimilar to that which occurs to cinnabar, in the making of vermilion. This is made by ſubjecting the cinnabar to a minute mechanical diviſion. But the effect of this diviſion is to interpoſe among it's particles an infinite number of molecules of air, which acting as opake matter, increaſe the reflection of light from the interior parts of the heap, and occaſion all the difference of appearance between theſe two ſtates of the ſame body.

Objection anſwered.

It may be ſaid in oppoſition, that granting an increaſed reflection of light from the interior parts of the blood in conſequence of air and neutral ſalts, ſtill this is not a ſufficient cauſe for the production of the colour; for after their action it is a ſcarlet, which according to Dr. Fordyce differs not only in brightneſs, but alſo in kind from the ordinary colour of blood, which is a modena red. The anſwer is, that there are examples, beſides that to which the objection is made, of dark blood appearing florid, merely from it's colouring matter being ſeen by means of an increaſed quantity of light. Thus by rubbing a piece of the darkeſt craſſamentum with a proper quantity of ſerum, the mixture in a few ſeconds takes a colour ſimilar to that given by common air. But nothing is done but interpoſing among the red globules a number of the leſs denſe particles of ſerum, which acting as opake matter increaſe the internal reflections. Likewiſe, on viewing by tranſmitted light the fine edges and angles of a piece of craſſamentum in water, their colour appears to be a bright ſcarlet, though all the other parts of the ſame maſs are black. Theſe facts appear to this chemiſt to be ſufficient to prove what has been already advanced; but he goes a ſtep further, and ſhows how the modena red is converted into a ſcarlet.

Appearance of colour.

Blood he found by experiment to be one of thoſe fluids, which Sir Iſaac Newton obſerved to appear yellow when viewed in very thin maſſes: when therefore a number of opake particles are formed in it by the action of common air and neutral ſalts, many of them muſt be ſituate immediately beneath the ſurface. The light reflected by theſe will conſequently be yellow, and the whole effect of the newly-formed opake particles, upon the appearance of the maſs, will be the ſame as if yellow had been added to it's former colour, a modena red. But modena red and yellow are the colours which compoſe ſcarlet.

Origin of the colour.

Upon the whole it appears to Dr. Wells, that blood derives it's colour from the peculiar organization of the animal matter of one of it's parts; for whenever this is deſtroyed, the colour diſappears, and can never be made to return, which would not be the caſe if it depended upon the preſence of any foreign ſubſtance whatever.

Miſcellaneous obſervations.

He concludes with ſeveral miſcellaneous facts reſpecting the colour of the blood, and ſome conſequences that may be derived from them.

Subſtances that tranſmit air to blood.

It had been mentioned by Dr. Prieſtley, that the only animal fluid beſide ſerum, which he found to tranſmit the influence of common air to blood, was milk. Dr. Wells has obſerved that the white of egg, or a ſolution of ſugar in water conveys the influence of air to blood, from which it ſeems probable that milk owes it's ſimilar property to the ſaccharine matter it contains. Mucilage of gum arabic had no ſuch effect.

Neither ſerum nor ſolutions of neutral ſalts extract colour from blood though they diſſolve the red part.

He found (contrary to what had been aſſerted before) that ſaturated ſolutions of all the neutral ſalts extract, though ſlowly, red tinctures from blood, ſome of which are very deep, and neither they nor ſerum, added in any proportion to a ſolution of the red matter in water, alter it's colour or tranſparency, except by diluting it. For having added a drachm of diſtilled water to an ounce of ſerum, the mixture was poured upon a ſmall piece of craſſamentum: and upon an equal piece of this laſt a drachm of water was poured, and an ounce of ſerum after ſome time was added. Each parcel therefore contained the ſame quantity of craſſamentum, ſerum and water, but the craſſamentum upon which the mixture of ſerum and water had been poured communicated no tinge to it, while the other piece, to which water had been firſt applied, and afterwards ſerum, gave a deep colour to the fluid above it. Similar experiments were made with craſſamentum, water, and a dilute ſolution of a neutral ſalt, which were attended with the ſame reſults.

Hewſon's obſervations on the red globules confirmed.

Since then neither ſerum, nor a dilute ſolution of a neutral ſalt, will extract colour from blood, though they are both capable of diſſolving the red matter, when ſeparated by water from the other parts of the maſs, it follows, according to this chemiſt, that the red globules conſiſt of two parts, one within the other, and that the outer, being inſoluble in ſerum or dilute ſolutions of neutral ſalts, defends the inner from the action of theſe fluids. The microſcopical obſervations of Hewſon led to the ſame concluſion, that the red globules conſiſt of two parts, an exterior veſicle and an interior ſolid ſphere. The exterior part of the globule appears to Dr. Wells to be that ingredient of the blood upon which common air and the neutral ſalts produce their immediate effect, when they render the whole maſs fluid, for they neither act on the red matter, nor do they occaſion any change in the coagulated lymph or ſerum. It ſeems evident alſo that there exiſts an animal matter in the blood, different from the coagulable lymph, the coagulable part of the ſerum, the putreſcent mucilage and the red particles.

Afford other explanations reſpecting the red globules.

Dr. Wells is of opinion, that although all reaſoning founded upon microſcopical experiments ought perhaps to be regarded as in great meaſure conjectural, yet thoſe of Hewſon appear likewiſe to furniſh a reaſon, why both water and a ſaturate ſolution of a neutral ſalt can extract colour from the red globules, though a mixture of thoſe fluids be incapable of the ſame effect. For water applied to the red globules ſeparates the exterior veſicles from the red particles, which are now open to the action of any ſolvent. The addition however of a ſmall quantity of a neutral ſalt to the water enables the veſicles to preſerve their ſhape and retain the inner ſphericles. On the addition of a larger quantity of ſalt the veſicles contract, and apply themſelves cloſely to the red particles within. Thus far Hewſon. Let it now be ſuppoſed that the veſicles contract ſtill more, from a further addition of ſalt to the water; then, as the internal particles are incompreſſible, the ſides of the veſicles will be rent, and their contents expoſed to the action of the ſurrounding fluid. Both water, and a ſtrong ſolution of a neutral ſalt, may therefore, according to Dr. Wells, deſtroy the organization of the veſicles, though in different ways, and thus agree in bringing the red matter in contact with a ſolvent, while a mixture of thoſe two fluids, viz. a dilute ſolution of a neutral ſalt, will, by hardening the veſicles, increaſe the defence of the red matter againſt the action of ſolvents.

Extended further by Dr. Wells.

Home.

From the experiments of Charles Grover inſtituted by Home, it appears the blood is capable of uniting with a quantity of urine equal to itſelf, ſo as to form a firm coagulum; that the red particles do not diſſolve in this coagulum, but it is diſſolved by the ſurrounding urine; that an admixture of urine prevents the blood from becoming putrid, and the coagulable lymph breaks down into parts nearly reſembling a ſoft powder. He was led to make theſe experiments from a circumſtance that happened to a patient. He had a rupture of a veſſel in one of the kidneys, and from the ſymptoms, it ſeems, that part of the blood which paſſed into the bladder from the kidney remained there and formed a coagulum, which coagulum gave a bloody tinge to the urine, and cauſed an inability to void it without aſſiſtance, till it was diſſolved by the urine. Experiments out of the body perfectly agreed with what happened in the bladder.

The laſt experiments on healthy blood were made to diſcover the quantity of carbon in it, which was found to exiſt in larger proportion in the arterial than in venous blood. 1. Abildgaard, on drying 100 parts of the venous blood of a horſe, by a moderate heat got 26 parts of a ſubſtance ſufficiently dry for pulverization, whilſt the ſame quantity of arterial blood afforded 25. 2. To alkalize, after Kirwan's method, 1 oz. of nitre by detonation (480 grains to the oz.) required 192 grains of venous, and only 160 of arterial blood. 3. An oz. of venous blood, after being dried and decompoſed in a cloſe veſſel, afforded 115 ½ grains of carbon, whilſt the ſame quantity of arterial blood only gave 87 ½ of carbon. 4. To decompoſe 480 grains of nitre, 148 grains of carbon of venous blood were neceſſary, but only 119 grains of that of arterial blood; this experiment, however, Abildgaard looked upon as not very exact, from a part of the carbon flying off like a duſt. The carbon of arterial was likewiſe much lighter than that of venous blood. 5. Having ſeparated the red part of the blood from the ſerum and fibrous part, it was dried and tried with nitre, and he found that 130 grains of this red part were neceſſary to alkalize 480 grains of nitre, whilſt it required 202 grains of fibrous part ſeparated from the ſerum, and well waſhed, to alkalize the ſame; this part however detonated with more vivacity than the other parts of the blood. Such are the experiments and obſervations that have been made on the nature and properties of blood in it's healthy ſtate.

Abildgaard.

Before the experiments of Parmentier and Deyeux, little or no attempt had been made to determine by analyſis the change that blood undergoes when affected by diſeaſe. The inveſtigation of theſe chemiſts was confined to the human blood, and the ſtandard, by which a compariſon of the products was made, was taken from healthy people of both ſexes, of good conſtitutions, and of different ages and temperaments. They found the blood of a

Diſeaſed blood.

young perſon, in general, to have a more lively red colour than that of a middle aged perſon; that the albumen of the ſerum does not acquire ſo much firmneſs; that the coagulum has leſs conſiſtence, and that the fibrous matter is not ſo abundant: as to the other products, they were ſimilar to thoſe which the blood of other animals afford; to which it may be added, that no notice was taken of the quantity of the products of different ſubjects, but only of the conſtituent parts, the comparative quantities varying more or leſs every day in the ſame ſubject.

In an inflamed ſtate.

The blood of perſons affected with inflammatory diſeaſes was firſt examined. Some was taken from a young man twenty-ſix years old, of a ſtrong and vigorous habit: he had been ſuddenly ſeized with a pain in his ſide, accompanied with fever, oppreſſion, and a ſpitting of blood.

This blood, on coming from the vein, was of a beautiful red colour, the coagulum was very ſoon formed, the ſerum ſeparated from it, and the ſurface of the coagulum was covered with a whitiſh ſolid *buff*, of the thickneſs of a crown piece, which when it had acquired all it's firmneſs, was ſeparated from the coagulum. The coagulated part was leſs conſiſtent than that of healthy blood; it very much reſembled red currant jelly, not ſufficiently boiled. Water readily diſſolved it, and at the ſame time ſome fibrous particles or pellicles, extremely thin and light, were obſerved to remain at the bottom of the veſſel, but which ſoon aroſe on the leaſt agitation. A part of the coagulum was put into a linen bag, and compreſſed at different times in water, by which means the fibrous part was left behind undiſſolved in the bag; it was in filaments, the ſame as in healthy blood when expoſed to the ſame proceſs. On expoſing the water of the lotions to a boiling heat, a thick red coloured matter was ſeparated, the phyſical properties of which did not appear to differ from thoſe of the ſame matter from healthy blood, and it afforded the ſame products.

Buff.

The *buff* (cruſta inflammatoria) which covered the ſurface of the coagulum, being waſhed in diſtilled water, became perfectly white, and preſerved it's conſiſtence and thickneſs; after having been wiped with blotting paper, it was ſupple and elaſtic, and formed an homogenous ſemitranſparent ſubſtance, without preſenting any fibrous texture or tearing; it reſembled a piece of white ſkin that had remained ſome time in water.

Sp. gr.

It's ſpecific gravity was leſs than that of water.

Water.

It was not affected by cold water, but on being digeſted in boiling water it reſembled fleſh in it's being acted upon, and it became hard.

Acids.

Very diluted acids had ſcarcely any effect upon it, but vegetable acids, particularly vinegar, completely diſſolved it, and theſe ſolutions were decompoſed by fixed alkalis.

Alkalis.

Fixed and volatile alkalis, in their mild ſtate, had very little or no action upon it, but in their cauſtic ſtate and by digeſtion, they diſſolved it.

Exſiccation.

It's exſiccation is ſoon effected by placing it upon the large mouth of a bottle, thus diminiſhing it's points of contact: in this ſituation, it loſes all it's humidity in the ſpace of twenty-four hours, and is reduced to a very thin ſemitranſparent ſubſtance, reſembling a piece of bladder. Before and after it's exſiccation, it affords the ſame products as the fibrous matter.

Putrefaction.

Expoſed to a humid air, it ſoon becomes putrid: it loſes it's conſiſtence by degrees, and is converted into a kind of puriform matter of ſo diſguſting an odour as to be difficult to ſupport.

Serum.

The *ſerum*, which, as before mentioned, ſeparates at the ſame time with the coagulum, was of a tranſparent lemon colour; from it's ſavour it appeared to contain fixed alkali, which was corroborated by it's changing the ſyrup of violets green.

Heat. Boiling water being poured upon it, no coagulation of the albumen took place, but the mixture became of a milky colour, and reſembled a ſolution of ſoap in water. Expoſed to the heat of a water bath (baln. Mar.) it loſt it's fluidity, and was converted into a white matter as thick as the hardened white of an egg, however, without entirely it's conſiſtence and continuity, as there appeared to be a ſmall quantity of fluid between it's particles which oppoſed their union. This matter contained ſulphur.

Alkalis. Cauſtic fixed alkali with this ſerum formed a mixture that was no longer coagulable by heat; it remained conſtantly fluid, but on adding ſome diſtilled vinegar to it, the liquor became turbid, and a flaky ſubſtance ſeparated which ſwam on it's ſurface; at the ſame time, a very ſenſible odour of ſulphurous hydrogenous gas was diſengaged.

Acids. Acids likewiſe do not trouble the tranſparency of this ſerum in a diluted ſtate, but they coagulate it when concentrated; this effect is more particularly produced by the ſulphuric acid.

Alcohol. This fluid is alſo acted upon by ſpirit of wine, for they ſcarcely come into contact when the mixture becomes turbid and milky.

Diſtillation. Laſtly, if this ſerum be diſtilled on the open fire, there are obtained phlegm, oil, fluid, and concrete ammonia; and a light and then a thick heavy oil. Towards the end of the proceſs, the matter tumefies, and at laſt, a light coal is found at the bottom of the retort, from which iron was extracted by the magnet; afterwards ſoda and muriat of ſoda were obtained by lixiviation and ſpontaneous evaporation.

Compared with healthy blood. Amongſt the different products which the analyſis of this inflammatory blood afforded, there are ſome that preſented characters not to be found in ordinary blood, ſuch are

1ſt. The buffy matter.

2d. The ſoft ſtate of the coagulum the ſurface of which was covered by the buff.

3d. The want of continuity of the albumen ſeparated from the ſerum by means of heat.

4th. The impoſſibility of producing the concretion of the albumen by pouring boiling water on the ſerum.

5th. The milky colour which the mixture receives.

Nature of the buff.

Amongſt all the products, the buffy part is one of thoſe which appears principally to have fixed the attention of authors who have written on the blood. Having been taught by obſervation, that it only exiſted under certain circumſtances, it's preſence was looked upon as indicating ſome diſeaſe, but they agreed very little reſpecting either it's nature, compoſition, properties, or origin.

Various opinions of it.

Thus Sydenham attributed it's origin to the lymphatic and fibrous part of the blood. Malpighi and Haller looked upon it as formed by the thickening of the chylous and nutritive matter of the blood. Queſnoy and Sauvages had no doubt of it's being perfectly formed pus, or nearly ſo; and Gabert, who had at firſt adopted the ſame opinion, afterwards abandoned it, and believed it to be one of the albuminous products which ſeparates from the ſerum. Hewſon, Moſcati, and Calliſon believed, that it ariſes from the craſſamentum. They explain it's formation by ſaying, that the blood, and particularly the coagulable part, is more diſſolved and diluted than other blood, on which account the more ſpecifically heavy red part has time to ſeparate and fall to the bottom, whilſt the lighter colourleſs part remains at the top; and they conclude, that the action of a real inflammation conſiſts in a leſſened coagulability of the blood. Bordeu and Robert regard it as the product of a ſort of mucilage with which the blood abounds. Hey, Lappenberg, and Burſenius, impute it to an increaſed coagulability of the blood, which is partly occaſioned by an internal change of it's previous mixture, and a proportionable increaſe of the fibrous part to the ſerum, and partly to the increaſe of the coagulable part of the ſerum. Gren likewiſe attributes it to the increaſed coagulability, and the increaſe of the fibrous part of the blood. According, however, to de Haen, Siveton, and Boerhaave, the buff is not always preſent in a true inflammation, and it exiſts ſometimes when this inflammation is not preſent; and Burſerius found it in the blood of horſes in their moſt perfect health. Such are the diverſity of opinions reſpecting this ſubſtance, but the perfect analogy which the above experiments ſhow there is between it and the fibrous matter leaves no doubt on it's nature. It ſtill remained to diſcover the manner in which the ſeparation of the buff takes place, which was done in the following manner:—

Separation of the buff.

Some blood, in which a buff was expected to form, was received in a porcelane veſſel, and every thing about to take place was examined with minute attention. It was obſerved, that in proportion as the blood approached towards coagulation, the firſt lineaments of the buff began to be formed upon it's ſurface. By means of a needle ſome of this buff was ſeparated; it appeared in the form of filaments, more or leſs long, their conſiſtence and elaſticity reſembling thoſe of the fibrous filaments. It was at firſt thought poſſible that the ſame ſeparation might be continued as the buff appeared, but the coagulation ſuddenly taking place, it's ſurface was covered with a pellicle, which ſoon became thick and put an end to the experiment; otherwiſe, the coagulum might have poſſibly been procured deprived of it's buff, which would have led to the theory of the formation of that ſubſtance, Opinion of Parmentier and Deyeux.

Admitting therefore, that the buff owes it's origin to the fibrous matter; which cannot be doubted, from it's poſſeſſing all the properties of that matter; it appears probable to Parmentier and Deyeux, that it's formation can only take place, becauſe the particles of the fibrous matter diſſolved in the blood, ſo long as they are endued with vital motion, loſe their ſolubility in proportion as the blood coagulates; afterwards from their ſpecific gravity they riſe to the ſurface, where by uniting, they give riſe to the ſolid body called buff. What appears to juſtify this explanation, is the facility with which the formation of this ſubſtance is prevented, for by ſeparating the fibrous matter by means of agitation, the particles of it not being then able to collect ſpontaneouſly together, muſt neceſſarily appear under another form; ſo that, inſtead of a homogenous ſubſtance poſſeſſing continuity and a ſort of texture, only oblong and elaſtic filaments are obtained, which are ſimilar in every reſpect to the fibrous matter. The natural denſity of the blood that furniſhes the buff undoubtedly facilitates the ſeparation of the fibrous matter, and places it in a favourable ſtate that it may collect itſelf; for when this denſity is diminiſhed by diluting the blood with water, no buff appears; or if it be formed, it has not the ſame conſiſtence as that which ariſes upon the blood when left to itſelf.

For the formation therefore of this buff, it is neceſſary that the blood have a certain degree of fluidity, above and under which the fibrous matter is not able to ſeparate itſelf; but ſince this fluidity naturally diminiſhes in proportion as the blood loſes it's vital principle, it is not extraordinary, that a certain quantity of fibrous matter ſhould always remain confounded with the ſubſtance of the coagulum, which may be obtained by waſhing the coagulum in water.

The ſeparation of the fibrous matter employed in forming the buff, may likewiſe be regarded as the cauſe of the ſoftneſs which, as above mentioned, is natural to the ſubſtance of the coagulum. Indeed, if, as has been already ſhown, the coagulum only owes it's conſiſtence to the preſence of a certain quantity of fibrous matter, the more inconſiderable the quantity of this matter is, the leſs will be the conſiſtence of the coagulum; hence it ought to be infinitely more ſoluble in water than that which is deprived of all it's fibrous matter. In ſhort, it would appear, that the fibrous matter, in order to enjoy the property it has of ſeparating to form the buff, has undergone ſome alteration from the action of the diſeaſe; which, although inſenſible to the chemiſt, is not ſo by it's effects in the animal economy during circulation.

Laſtly, the fibrous matter is not the only conſtituent part of the blood on which the diſeaſe appears to have acted; it's effects may be likewiſe remarked in a very ſenſible manner on the albumen; for it has been before obſerved, that it was coagulated with great difficulty by heat, and that once ſeparated, it had never that conſiſtence and continuity which it has when ſeparated from the ſerum of healthy blood by the ſame means.

Before concluding this article on inflammatory blood, it may be obſerved, that on examining the blood of many patients, affected with inflammatory diſeaſes, very ſenſible differences in the reſults are often to be obſerved. Sometimes the buffy part is very thick, at other times very thin; ſometimes the ſerum is in large quantity, at other times in ſmall quantity, and ſeparated from the coagulum with great difficulty; likewiſe, the blood of different diſeaſed people has different ſhades of colour. From theſe obſervations, the two chemiſts have acquired the moſt complete proof of the difficulty, or rather impoſſibility of finding any two bloods perfectly ſimilar;

which is eaſily conceived on reflecting upon the diverſity of accidents which, independent of the temperaments of each individual, always accompany inflammatory diſeaſes, and which have a more or leſs marked influence not only on this fluid, but even on the other fluids of the animal ſyſtem.

Blood of ſcorbutic perſons.

The next object of theſe chemiſts, was the inveſtigation of the blood of perſons affected with the ſcurvy; for this purpoſe they examined three patients who had the characteriſtic ſymptoms of this diſeaſe. Two of theſe were between twenty-nine and thirty years old, the third was forty-ſeven. The firſt was affected with pains in his ſide, independently of the ſymptoms of the diſeaſe, for which veneſection was ordered: the ſecond, and more particulary the third, had a general plethora, and the expectation of hemorrhage neceſſitated the act of V. S.

Firſt patient. This blood had a red colour with little brightneſs; the coagulum took place very readily, the ſerum was ſlightly lemon-coloured and tranſparent, and the quantity not greater than that of inflammatory blood. It's taſte was alkaline; it changed the ſyrup of violets green, mixed with acids without efferveſcence, and without loſing it's tranſparency; but it was coagulated by concentrated acids, alcohol, ether, and all dephlegmated ſpirituous liquors, which alſo produced a whitiſh matter in it that ſuddenly fell to the bottom of the veſſel; alkalis increaſed it's fluidity. Expoſed to the heat of boiling water, the ſerum coagulated, but not ſo firmly as in a healthy ſtate; and when this coagulated ſerum was ſlightly preſſed, a limpid and colourleſs liquor was obtained, which did not change the ſyrup of violets. The matter remaining upon the linen had all the properties of the albumen of the blood.

The coagulum of the blood, a ſhort time after it's formation, loſt a part of it's volume, but at the ſame time a ſmall quantity of ſerum ran from it. It's ſurface did not preſent that lively and bright red froth which is obſerved in healthy blood, but it was covered with ſo thin a pellicle as not to prevent the ſubſtance of the coagulum from being diſtinguiſhed underneath; the tenacity of this pellicle prevented it's being ſeparated. The conſiſtence of the coagulum was the ſame as in ordinary blood, and the fibrous matter ſeparated by means of water, was in as great a quantity, and as firm and elaſtic.

Second patient. The ſeparation took place in this blood as in the preceding; the pellicle that covered it was whitiſh and ſomewhat thick; it's conſiſtence, however, was not very ſtrong, as the leaſt preſſure was ſufficient to tear it. The ſmall portions taken after the ablutions, were white and ſemitranſparent, and reſembled thoſe obtained from the long agitation of a piece of coagulum in cold water: on red-hot coals they were deſtroyed, giving an odour of burnt coal; they were diſſolved by vinegar and cauſtic alkalis; but alcohol, on the contrary, made them ſolid.

The ſerum had nothing in particular.

Third patient. This blood was decidedly buffy, but the buff was not ſo thick as that of inflammatory blood, yet more firm than that of the ſecond patient: it was eaſily waſhed in water without tearing; by waſhing it became very thin, but preſerved it's tranſparency; boiling water, vegetable acids, alkalis and alcohol had the ſame effect upon it as on common buff; on exſiccation it was reduced to ſo friable a leaf as to be divided into ſeveral parts on the leaſt touch. The ſubſtance of the coagulum under this buff had a ſpecies of ſoftneſs which permitted the water to diſſolve it very eaſily, whilſt at the ſame time, ſome membranous pellicles ſeparated from it; and fell to the bottom of the veſſel. This coagulum incloſed in a linen bag, and waſhed with water, afforded, after ſolution, ſome very elaſtic fibrous filament.

The ſerum, and the red part, coagulated, appeared the ſame as thoſe of the blood of the two firſt patients.

Obſervations.

On taking a general view of the blood of the three patients, it was obſerved, that none of them had that peculiar odour which is ſo marked in healthy blood. This difference in the odorous principle, and a more or leſs diſproportion to form buff, are the only eſſential differences to be obſerved in theſe three ſcorbutic patients. Theſe chemiſts found the deſcription of authors, who ſay, that the blood of ſcorbutic perſons is more fluid than ordinary, not to be true, for it has very nearly the very ſame properties as healthy blood; it affords a coagulum of much conſiſtence, and the quantity of ſerum is not more conſiderable. They obſerved, that if the ſerum was greater in quantity from one bleeding, the remainder was leſs voluminous, and *vice verſa*; the conſiſtence of that which afforded the leaſt ſerum, leſs firm, whilſt on dividing it a quantity of ſerum flows out that had been detained between its parts; that the more ſerum it affords, the leſs runs from it afterwards; and therefore, if the quantity of ſerum of one bleeding be compared with that of another, from the ſpontaneous ſeparation and diviſion of the coagulum, very little difference will be perceived; from which it would appear that all indications drawn from the apparent quantity of ſerum of the blood, are often erroneous.

The greater or leſs opening in the vein, the greater or leſs conſiderable quickneſs with which the blood flows from it, the more or leſs marked weakneſs of the patient, the form of the veſſel in which the blood is received, and the motion and agitation which it is ſcarcely impoſſible to avoid, may be conſidered as the principal cauſes which haſten or retard the formation of the coagulum, and of it's ſometimes retaining a large quantity of ſerum; whilſt, at other times, it lets a greater or leſs quantity eſcape. It is not however to be ſuppoſed, that in all circumſtances the blood of diſeaſed people is equally ſerous; at the ſame time, it is an error in thoſe phyſiologiſts who have advanced, that the fluidity of the blood of ſcorbutic people was more decidedly marked than that of the blood obtained in other diſeaſes.

One reaſon of their having attributed this more than ordinary fluidity to ſcorbutic blood, appears to have been the facility with which it eſcapes from the veſſels in that diſeaſe, and which Parmentier and Deyeux attribute to the debility of the veſſels; which not being able to reſiſt the leaſt efforts, are eaſily torn and let the fluid they contain eſcape; hence, the hemorrhages from the gums and noſe of ſcorbutic people. The ſame happens in old people who are bled; their blood flows ſlowly, which is attributed to the ſame cauſe, the debility and flaccidity of the vaſcular ſyſtem; and in many caſes, old people finiſh their career by diſeaſes that are very analogous to the ſcurvy. To the ſame cauſes, *viz.* the veſſels being torn, and an extravaſation taking place under the ſegments, theſe chemiſts think, thoſe blue ſpots originate that are to be ſeen upon the legs of ſcorbutic patients.

Blood of perſons under putrid diſeaſes.

The laſt diſeaſed blood which Parmentier and Deyeux examined, was that taken from patients affected with putrid fevers. From their experiments it appears, that the blood of theſe patients was never alike. Sometimes the firſt bleeding afforded a very buffy blood; at other times the buff was very inconſiderable in quantity, and ſometimes it was not preſent; it was likewiſe to be remarked, that the ſerum eaſily ſeparated from the coagulum, although the ſeparation was oftener more difficult.

The productſ by analyſis preſented nothing extraordinary; the buff appeared ſimilar to that in inflammatory diſeaſes; likewiſe, the ſubſtance of the coagulum beneath it had very little conſiſtence, and was very ſoluble in water, which ſolution was coagulated by the action of heat, alcohol, and concentrated acids; whilſt, on the contrary, fixed and volatile alkalis oppoſed it's coagulation, and ſingularly exalted its colour.

It was expected, on ſubmitting it to diſtillation on the water-bath, that if the principle of putridity really did exiſt in the blood, proofs of it would be found in the products, ſuch as volatile alkali, which is always obtained from ſubſtances in which putridity has taken place; but inſtead of this, a clear colourleſs fluid only was obtained, having the odour and light ſavour of blood, and which had no effect on the ſyrup of violets. It was alſo obſerved, that diſeaſed and healthy blood expoſed to the ſame temperature, was nearly the ſame time in becoming putrid; from which it is concluded, that in putrid diſeaſes, the principle of putridity does not exiſt in the blood.

General recapitulation.

On taking a general ſurvey of the experiments, and recapitulating the obſervations and concluſions of Parmentier and Deyeux, on the nature and analyſis of blood, it conſiſts therefore of nine principal parts, *viz.* the odorous part, or aroma. Fibrous matter. Gelatin. Albumen. Red part. Iron. Sulphur. Alkali or ſoda; and water. The proportion of theſe parts vary almoſt infinitely, according to the age, temperament, and the manner of living; all of them having characters that eſſentially belong to them, with particular ſhades, which are often difficult to lay hold of.

Aroma.

1ſt. Odorous part. In the healthy ſubject, this part is very ſenſible, eſpecially when the blood is freſh; by degrees it becomes weaker, in proportion to the change the blood undergoes, and it entirely diſappears when putridity takes place. In the blood of the diſeaſed ſubject, the aroma is leſs decidedly marked; it is even probable, that in certain caſes it is wanting. It appears that it's affinity for the ſerum is leſs than that which it has for the coagulum; for this laſt ſubſtance preſerves it entirely for ſome time; whilſt the ſerum, when perfectly ſeparated, is devoid of it. It ſeems to have a very ſenſible analogy with the aroma of vegetables, ſince both of them, independent of their action upon the organs of ſmell, are ſoluble in water, in air, and in ſpirituous liquors.

Fibrin.

2. Fibrous matter. This matter appears to exiſt in the blood, if not in a ſtate of ſolution, at leaſt in a ſtate of extreme diviſion. To bring about the ſeparation, a rapid motion of this fluid is ſufficient; or it may be obtained by diluting it with a certain quantity of water. In the firſt caſe, the fibrous matter is obtained in the form of filaments, adhering together, and producing a body of ſome elaſticity; in the ſecond caſe, on the contrary, it is precipitated in the form of membranous particles; both of them, however, when treated with chemical agents, afford conſtantly the ſame reſults, that is, thoſe which belong to animal matters in general.

In young animals, the fibrous matter appears to be leſs tenacious in conſiſtence than in the adult, in which the tenacity is more evident; but neither in health nor in diſeaſe is there any other difference than what reſpects the age; ſo that the fibrin ſeparated from the blood of a healthy, vigorous perſon of middle age, very nearly reſembles that of the blood of patients labouring under ſcorbutic, putrid, or inflammatory diſeaſes.

It is the fibrous matter that contributes to the formation of the coagulum, which was a long time attributed to the loſs of the natural heat of the blood; but which is in reality the conſequence of the contraction this matter undergoes on loſing the principle of life.

3. Gelatin. Many very celebrated phyſiologiſts have Gelatin. ſuppoſed that the blood contained a certain quantity of gelatinous matter. Rouelle and other chemiſts having ſought for it in vain, denied it's exiſtence; Fourcroy however was aſſured that he had obtained it alone, and diſengaged from every foreign body. The aqueous fluids being the natural menſtrua of this matter, it may be ſuppoſed that the ſerum would draw it along with it, and it there remains confounded with the albumen, the neutral ſalts and the ſoda, but it is eaſily ſeparated on coagulating the ſerum. There is therefore no doubt of it's exiſtence. The quantity however of gelatin is very inconſiderable in the blood, and it is perhaps on this account that it's diſcovery has been ſo long prevented. It is probable, that in proportion as it is formed, a part of it ſeparates, which is deſtined with the fibrin to the formation of the muſcular ſubſtance. The morbific action ſeems to have no influence on the gelatin, for in the blood of the before-mentioned diſeaſed patients it was found to enjoy all it's properties, and it may be obſerved on concluding this article, that Hippocrates and Bordeau were not deceived in ſaying, that the blood was melted and running fleſh, ſince the two matters that conſtitute fleſh are found in this fluid.

4. Albumen. Whilſt the blood has not undergone Albumen. any change, this particular matter remains in ſolution in the ſerum, but on the ſmalleſt decompoſition of the blood it ſeparates into two parts the one of which unites with the ſerum and gives it a kind of unctuoſity; the other on the contrary, joins the fibrin and colouring part. Since then, it's concretion can only take place from the loſs of a certain quantity of water that diſſolved it, it becomes of

confiſtence which it partakes of with the two bodies with which it is found mixed.

It is the concretion of the albumen that contributes to the formation of the coagulum by means of the fibrin, and as the concretion of the albumen takes place in this caſe ſpontaneouſly and without the aid of heat, it cannot have loſt the property of being ſoluble in a freſh quantity of water; and this is alſo the reaſon of the coagulum being entirely ſoluble in water, whilſt the albumen ſeparated by heat or acids is no longer ſoluble in aqueous fluids.

The ſoda or fixed alkali appears to contribute to the ſolubility of the albumen. Theſe two bodies are indeed in a ſort of ſlight combination, ſince heat, ſpirit of wine and certain acids are capable of deſtroying it, and of cauſing the albumen to appear, which immediately loſes the property of being ſoluble in water.

On comparing the albumen of the blood with that of the white of egg, and of other animal fluids, they are perfectly ſimilar, at leaſt they have the ſame properties, and ſulphur is likewiſe found in them.

Of all the conſtituent parts of the blood, the albumen is that which ſeemed to undergo the greateſt alterations from diſeaſe. In particular it became ſenſible on heating the ſerum that held it in ſolution, and it then never acquired that complete concretion which the ſerum of healthy blood always had when treated in the ſame manner. A certain quantity of liquor ſeparated, which was eaſily extracted by ſimple decantation. This change however is not peculiar to any particular diſorder, nor could differences be obtained with every precaution, that were ſufficiently ſenſible to take any account of.

Colouring matter.

5. Red part. This part of the blood varies infinitely in it's ſhades. In general, the colour of the blood of youth is vermilion, whilſt that of old age is darker coloured. It is likewiſe well known, that venous blood is

of a leſs lively red than arterial, and that the ſhades in the colour of this fluid are very numerous. It was impoſſible to obtain the colouring part, diſengaged of foreign matter, but it appears to be always accompanied with a certain portion of albumen, to which it has a decided relation. Their ſolubility in water and their inſolubility in ſpirit of wine, as well as in other menſtrua, are the cauſes that oppoſe their ſeparation, and prevent the acquirement of the knowledge that might be had of it, if it could be obtained by itſelf. It appears however to be the opinion of Parmentier and Deyeux, that iron acts a great part in the coloration of the blood, and that it's ſolution is produced in this fluid by the ſoda.

6. Iron. This metal is only contained in the red part of the blood, which appears from experiments to be Iron. held in ſolution, as obſerved, by the alkali, and it is this ſolution that produces the red colour, but what becomes of the iron on quitting the blood, chemiſtry has not yet been able to decide; the moſt extraordinary circumſtance however, is, that the muſcular part which is ſuppoſed to be entirely produced by the blood, does not contain the leaſt atom of this metal.

7. Sulphur. It is difficult to determine the ſtate in which this ſubſtance is found in the albumen, but it appears Sulphur. to be one of it's conſtituent parts. It moſt probably acts a great part in the animal economy, ſince independent of what is found in the albumen of the blood, it exiſts in the bile, the brain, and in all the humours where albumen is preſent.

8. Fixed alkali or ſoda. This alkali always accompanies Soda. the blood, and is in ſufficient quantity always to be eaſily obtained from it; moſt probably one of it's principal functions is to favour the ſolution of bodies, which without it's action would remain inſoluble, ſuch as iron and albumen. It is alſo probable, that it's utility is

more extenſive, as would appear from it's tendency to combination, and the property it has of communicating it to bodies with which it is ſound united. It appears to be always in a cauſtic ſtate, whether in the blood or other humours of the body, and may be conſidered as their eſſential ſalt. In the blood it more eſpecially becomes the *medium junctionis* of the albumen with the ſerum, and it's proportion in this fluid is more conſiderable than that of the albumen and iron.

Water.

9. Water. The fluidity of the blood eſſentially depends upon the water it contains, it facilitates the motion of the bodies that conſtitute it, and renders them proper to enter into the compoſition of the different parts to the formation of which it concurs. If water be compoſed of hydrogen and oxygen, it ought to be preſumed, that it is continually forming in the animal ſyſtem, and that independent of the quantity neceſſary to give fluidity to the blood, there is another portion decompoſed during the act of circulation, the reſults of which decompoſition contribute to repair the ſuppoſed loſſes either of the fibrin or albumen.

The blood does not always contain an equal quantity of water, hence it's fluidity is not always the ſame; but it is certain, that from it's greater or leſs fluidity, the leaſt conſequence cannot be drawn, ſo as to throw any light on the healthy or morbific ſtate of the ſubject from whom the blood was drawn, ſince from comparative experiments on the blood of both, infinite variations were obſerved.

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MILK.

Milk. This is a more or leſs white opake fluid, ſecreted from the blood in the breaſt of the female ſex, for the ſupport of their young during the firſt ſtage of life. The mammalia and cetacea are the only tribes that afford it; on which account they are called lactiferous animals, all others being found deſtitute of the organs that ſecrete it.

It is remarkable for containing a quantity of ſaccharine matter in one of it's component parts, and a much greater abundance of the earth of bones or phoſphat of lime than any other animal fluid; by which it appears, that nature was deſirous of affording a ſupply of nouriſhment and of oſſeous matter in proportion to the rapidity of the formation and increaſe of the bones and other parts, during the firſt ſeaſon of animal exiſtence.

It's properties.

Milk, as it is drawn from the animal, has a mild faint ſmell, which is peculiar to the ſpecies it is taken from. This is the odour that is expreſſed by the vulgar ſaying, it ſmells of the cow, the goat, the aſs, the ſheep, or the mare. As the milk becomes cool, this aroma goes off; it is likewiſe expelled by expoſure to heat.

To the taſte, it is pleaſant and more or leſs ſweet, and although this laſt property is ſcarcely perceptible in the milk of ſome animals, it is however always mild. To the touch it is ſomewhat unctuous.

It's ſpecific gravity is greater than that of diſtilled water.

When examined by the microſcope, a multitude of globules are ſeen of unequal ſize, and if we may give credit to Leuenhoeck, milk is compoſed of tranſparent globules carried in the ſame manner as thoſe of the blood in a diaphanous liquid.

Spontaneous ſeparation into three parts.

Since tranſparency and limpidity are the moſt certain marks of a real ſolution, it might be expected from the opacity of this fluid, that a portion at leaſt of it's contents was only ſuſpended in it; and ſuch is the caſe, for if freſh milk be left to repoſe ſome time in a cool ſituation, a ſpontaneous ſeparation takes place between it's parts. In the firſt place, there ariſes to the ſurface a more or leſs thick tenacious ſubſtance, the *cream*. When this has been taken off, the remainder goes by the name of ſkimmed milk; it is then of a bluiſh caſt, and has a leſs mild ſavour and is more fluid than before. Some time afterwards, the coagulable or caſeous part of the milk ſeparates, which is called *curd*. And this ſeparation is more quickly effected if the atmoſphere be warm, by producing a ſlight acetous fermentation ſooner than would otherwiſe have taken place. When this curd has been taken from it by filtration, the remaining fluid is called *whey*, or the ſerum of milk. The coagulation of milk does not take place in vacuo.

Artificial ſeparation by acids, vegetables.

A ſeparation of the caſeous part, or curd, may likewiſe be effected artificially by means of chemical reagents; thus milk is coagulated by all acids except the carbonic and weaker acids; by certain vegetables, as galium, vallantia cruciata, madder, thiſtle, &c. But according to the obſervation of Jacquin, theſe only act when added to milk in the cold, or when it is mixed with a cold aqueous infuſion of them; for if theſe vegetables be boiled in milk, or thrown into hot milk, the coagulation, inſtead of being promoted, is rather retarded; nor has the infuſion of theſe plants prepared by heat, their decoction, or even their diſtilled water any effect upon milk; by mucous bodies, as gum arabic, albumen, ſugar, &c.; by all ſalts, more eſpecially if they contain an exceſs of acid; as cream of tartar, ſalts of ſuccinum, benzoin, &c. by all metallic ſolutions; and laſtly, by alcohol and all ſpirituous liquors, whilſt this coagulum is rendered more perfect by means of heat.

Alkalis.

The mild alkalis likewiſe coagulate milk, but in a different manner from the ſubſtances before mentioned, for they unite with the butter and cheeſe, and form a kind of ſaponaceous maſs, ſeparating from the milk in the form of denſe white flocculi, which by continued ebullition become yellow, and at length brown.

The cauſtic alkalis diſſolve the coagulum or caſeous part, and hence they make milk more fluid inſtead of coagulating it.

Lime water produces an imperfect coagulation.

The electric fluid appears to thicken it more or leſs.

Freſh milk neither changes the colour of the tincture of litmus, nor of the ſyrup of violets; hence it is neither acid nor alkali.

With reſpect to other ſubſtances mentioned by authors as producing various effects on milk, they will be given when each kind of milk is treated of individually. It may be added, at the ſame time, that this fluid is ſo ſuſceptible of variation, not only in different ſpecies of animals, but in the ſame female at different times, from numberleſs circumſtances; ſuch as age, ſeaſon, nutriment, &c. that it is almoſt impoſſible to meet with two milks that do not differ from each other.

Heat at firſt renders milk more fluid, and it becomes concrete at the freezing points.

Expoſed to heat.

If freſh milk be expoſed to a gentle diſtilling heat on a water bath, there ariſes a fat pellicle, which is ſucceeded by others, a part of which being attached to the ſides or bottom of the veſſel, dries and torrifies, communicating to the fluid a diſagreeable empyreumatic taſte and odour, commonly called *potrether*, and which it cannot afterwards be deprived of; it may, however, be prevented by frequent ſtirring the fluid; if the ſerum is to be obtained, it is neceſſary to take away the pellicles as they appear, and replace the fluid in proportion as it evaporates by diſtilled water.

The ſerum obtained by this method is, on filtration, very clear, and by ſpontaneous evaporation affords ſugar of milk, and the other ſalts it held in ſolution. Theſe pellicles do not form without the contact of the air, ſince a combination with oxygen is as neceſſary in this caſe as in the ſpontaneous coagulation of milk. If theſe pellicles be waſhed, they appear like ſemipellucid membranes, very much reſembling thoſe that line the ſhells of eggs. They form the caſeous part, and very ſoon become putrid on expoſure to the air.

If the ebullition of the milk be ſo accelerated as to prevent the formation of the pellicles, and the products be examined, there is found in the receiver an inſipid clear water, impregnated with the aroma of milk, which ſoon becomes putrid. The part remaining in the retort is either in the ſtate of a moiſt or dry extract, which, when diſſolved in hot water, affords the original milk, but deſtitute of it's peculiar aroma. If this extract be expoſed to a ſtronger degree of heat, as on the ſand bath, it affords an empyreumatic acid and oil, ammonia, and hydrogen and carbonic acid gaſes. The reſiduum in the retort is a black coal, the aſhes of which, on incineration, give potaſh, muriat of potaſh and phoſphat of lime, with a little iron. Extract of milk.

New milk, if left to itſelf, undergoes the acetous fermentation; this in cold weather requires ſeveral days, but in a warm temperature, twenty-four hours are ſufficient for that purpoſe. It appears, that the milk of the ruminating claſs becomes ſour ſooner than that of the others: the milk of the ſheep is ſaid to undergo this fermentation the ſooneſt; and that of the mare, the lateſt. Milks, when rendered ſour, are uſed by different nations as drink or food. Acetous fermentation.

Milk becomes ſuddenly acid from ſudden changes in in the atmoſphere, and from ſtormy ſeaſons, but this propenſity to change may be in ſome meaſure prevented by previous boiling, it will then keep for ſeveral days, but boiled milk, however, ſooner paſſes into the putrid ſtate.

If freſh milk be put into a moderately warm place, and often ſtirred, ſo as to prevent a ſpontaneous ſeparation of it's parts, it undergoes the vinous fermentation, and on diſtillation, a ſtrong ſpirit is obtained; this is ſooner brought about by the addition of a fermenting ſubſtance. According to Stipriaan, the greateſt quantity of ſpirit was obtained from the milk of the cow; whilſt Plenck affirms, the mare, from the greater abundance of ſugar it affords, ferments the ſooneſt. Vinous.

Putrid. There is no animal fluid, if the gaſtric juice be perhaps excepted, that undergoes the putrid fermentation with ſo much difficulty as milk: according to Stipriaan, the milk of the cow remained four two months in the middle of ſummer without any ſigns of putridity; that of the aſs three months before any ammonia was produced; likewiſe the human milk was kept many months without becoming putrid; hence the difference of nouriſhment appears to have no influence in this reſpect.

The next part of this ſubject that is to be conſidered, is an examination of the three parts which are the products of ſpontaneous ſeparation in milk, *viz.* cream, curd and whey.

Cream. *Cream.* This part of the milk which is the lighteſt, and conſequently ariſes to the ſurface, contains a fat or oil, which, on being expoſed to the air, the mechanical operation of churning, and a certain degree of warmth, is procured in a concrete form called butter; for which *vide* animal oils.

The remaining fluid is white, and is the ſerum of milk, containing ſome of the caſeous and butyraceous parts; it is ſweet or ſour according to the ſweetneſs or acidity of the cream employed, and is called *Butter-milk.* According to Stipriaan, the milk of the ſheep affords the greateſt quantity of cream; then follow the human, and thoſe of the goat and cow, whilſt the aſs and mare give the ſmalleſt quantity. It appears, however, that the cream of the ſheep and goat is the thickeſt; and that from the milk of the human female, of the aſs, and of the mare, the thinneſt. All bodies which render fat oils ſoluble in water, impede the ſeparation of butter. The extremes of heat and cold do the ſame.

Curd. *Curd.* This coagulated part of milk, when freſh, is a white jelly-like ſubſtance, ſomewhat elaſtic, but is of more or leſs conſiſtence according as it contains more or leſs ſerum; it breaks readily with a rough fracture; is nearly without ſmell or taſte; inſoluble in water; becomes hard in hot water; is readily diſſolved by acids, forming with the vitriolic and muriatic brown ſolutions; and with the nitrous acid, a yellow ſolution; but the marine acid does not diſſolve it ſo readily as the other two. It is likewiſe eaſily diſſolved by the alkalis, pure or carbonated; but the vegetable has the leaſt effect upon it. During it's ſolution with the cauſtic mineral alkali, a putrid volatile alkaline ſmell ariſes.

By diſtillation, it affords a taſteleſs water that eaſily putrifies; on increaſing the heat, it bliſters, ſwells like burnt horn, affords hydrogen and carbonic acid gas, ammonia, partly fixed, partly fluid, and a heavy ſtinking empyreumatic oil. The coal is in great quantity, and difficult to incinerate. The aſhes contain lime, and phoſphat of lime, to which ſome chemiſts have added iron. Curd or cheeſe, on expoſure to a ſtrong heat, ſoftens, melts in ſome meaſure, loſes it's opake white colour, acquires a tranſparency and toughneſs like horn, throws out more or leſs of it's butyraceous or oily parts, and when cool, become hard and brittle. In ſhort, curd has all the properties of albumen.

Curd is of various conſiſtence in different milks; that of the milk of the goat and cow is ſolid and elaſtic; of the aſs and mare leſs ſolid; that of the ſheep only glutinous; whilſt the cheeſy part of the human milk is never ſolid, but always fluid, and it's ſeparation is attended with difficulty, and ſeldom ſpontaneous.

Curd, when ſalted and compreſſed, forms common cheeſe. If this be prepared from new milk, containing all it's cream, the cheeſe is rich and good; but if from ſkimmed milk, which contains but a little butyraceous portion, the cheeſe is meagre and bad. In the making of cheeſe, ſince the coagulation of milk is imperfect by repoſe alone, from the whey ſtill containing too many of the caſeous particles; and as the time it takes is long and uncertain, the artificial means of coagulating it have been reſorted to. For this purpoſe, the moiſt or dried ſtomach of a calf is generally employed, known by the name of rennet. It is the fourth ſtomach of the ruminating claſs, and it's power is owing to it's gastric juice, which is ſecreted from the middle coat of that organ.

Whey. *Whey.* The ſerum of milk, or the fluid that remains after the ſeparation of the cream and curd, is of a yellowiſh colour; has a ſweet agreeable taſte; and when the milk has undergone no previous acidity, and prepared without boiling, poſſeſſes the odour of milk. It is always turbid, and is beſt clarified by the white of egg. It is called *ſweet whey.* It is ſometimes uſed in medicine, Sweet. and is prepared by adding half a drachm of pulverized cream of tartar, or a few tea ſpoonfulls of lemon-juice to a pint of milk, brought to the boiling point, and this is continued until all the caſeous particles are ſeparated, it is then to be clarified by the white of egg, or deprived of it's ſuperabundant acid by a little calcareous earth.

By diſtillation of this whey on the water-bath, the ſame water is obtained as from new milk, and there remains a maſs, which, when freed from it's cheeſy, and other adhering parts, ſhoots into white rhomboidal cryſtals, termed ſugar of milk.

Sour. If, on the contrary, the milk has been previouſly ſour before coagulation, the liquor that remains is called *ſour whey.* Sweet whey, likewiſe by reſt, will undergo the acetous fermentation; and we are informed, by Jacquin, that by the addition of a ſmall portion of ſpirit of wine, and ſubſequent fermentation, a true vinegar of milk may be prepared. This acidity of milk is attributed by chemiſts to the ſaccharine part, for they find that the ſooner the whey is become ſour by ſpontaneous fermentation, the ſmaller is the quantity of ſugar that is left, vide *Lactic acid.*

Sugar of milk.

The ſugar of milk is of an opake white colour, has an inſipid ſweetneſs and ſomewhat earthy flavour. It is perfectly ſoluble in four parts of boiling water. When diſtilled by a ſtrong heat, it exhibits the ſame appearances as common ſugar. Rouelle extracted from one pound of this ſalt when calcined, from twenty-four to thirty grains of aſhes; three-fourths of which were muriat of potaſh, and the other fourth carbonat of potaſh. Placed on a lighted coal the ſugar of milk melts, ſwells, exhales an odour of ſugar candy, and burns like common ſugar. Theſe properties induced chemiſts to ſuſpect that, like ſugar, it would afford the oxalic acid by means of nitric acid, which Scheele confirmed by experiment; but it required a great deal of nitric acid to obtain it. He procured five drachms of oxalic acid from four ounces of ſugar of milk, and he obſerved, on diluting with water the reſiduum of the ſugar of milk treated in this manner, and on filtering it, in order to evaporate and cryſtallize the oxalic acid, that a white powder remained on the filter which had rendered the ſolution turbid; and on examining this acid, he found it to be a peculiar acid, the *ſaccholactic acid,* for which *vide* Acids.

Milk, therefore, from the above analyſis, conſiſts of the following proximate component parts: a fat oil, an albuminous ſubſtance, an eſſential ſalt and water. Some chemiſts, and particularly Macquer and Morveau, have looked upon it as a real animal emulſion, in which the oil is put into a ſaponaceous ſtate by the intervention of the mucous or caſeous part and ſaline principles; but the neceſſity of oxygen in the ſeparation of the butter and albumen, and the other phyſical properties it poſſeſſes, are, perhaps, ſufficient proofs of milk not being an emulſion. It appears, however, that milk may in ſome meaſure be compared to the juices of expreſſed fruits; it is opake, mild, ſaccharine, nutritive, and contains an eſſential ſalt. Like them, a decompoſition readily takes place, which gives riſe to products analogous to thoſe of wine, *i. e.* an ardent ſpirit and vinegar. It was alſo obſerved by Parmentier and Deyeux, that the thickeſt milk required the longeſt time for the fermentative proceſs to take place; that it furniſhed the greateſt quantity of ardent ſpirit, and that this ſpirit was not evident on diſtillation before the milk has paſſed to the acetous ſtate, which equally happens to cyder, perry, &c. It is to facilitate the fermenteſcible parts becoming acid that the Ruſſian Tartars add a certain quantity of oatmeal to their mares milk, and that they take care not to diſtil it until the mixture is ſtrongly ſour, for by this means they obtain more ſpirit. Milk likewiſe unites a number of properties analogous to the lymphatic and albuminous matter; hence it is employed with advantage to clarify wines, and particularly ratifiats, to which it communicates that marrowy ſavour not to be procured by any other means; for this purpoſe, however, it muſt be freſh, otherwiſe it does harm. It is therefore from it's undergoing the vinous and acetous fermentations, as well as the difficulty of becoming putrid, that milk approaches to the nature of the vegetable kingdom; and from it's containing a quantity of albumen in the caſeous matter, that it reſembles the animal kingdom.

The remote component parts of milk are therefore oxygen, hydrogen, carbon, azot, ſoda, phoſphorus and lime, to which ſome chemiſts have added iron.

HISTORY OF MILK.

It would be in vain to attempt to give any ſatisfactory

Cream.

Butter.

account of the firſt knowledge of the component parts of milk, and it's ſpontaneous changes. Milk was undoubtedly made uſe of as an aliment, by the earlieſt inhabitants of antiquity; for hiſtory informs us, that the riches of Abraham and Iſaac conſiſted for the moſt part in their herds. It is likewiſe very evident, that cream, from it's ſo ſoon appearing on the ſurface, muſt have been very early obſerved, and from it's delicious flavour, muſt, no doubt, have been eſteemed a great dainty; but there is reaſon to believe that butter, which forms ſo leading a feature in this fluid, was a much later diſcovery. It is true, that the tranſlators of the bible have made uſe of this word, but the beſt critics are of opinion, that the word *camea* ſignifies milk or cream, or ſour thick milk, and not butter, as it alludes to ſomething liquid. "When I waſhed my ſteps with butter, and the rock poured me out rivers of oil." Job. ch. 29. v. 6. "He ſhall not ſee the rivers, the floods, the brooks of honey and butter." Ibid. ch. 20. v. 17. It is likewiſe the opinion of the learned Michaelis, that the tranſlators of the bible who lived two hundred years after Hippocrates, and reſided in Egypt, and who have tranſlated the word by *Butyron*, meant cream. The oldeſt mention of butter, according to profeſſor Beckmann, though very obſcure, is by Herodotus, in his account of the Scythians. "Theſe people," ſays he, "pour the milk of their mares into wooden veſſels, cauſe it to be violently ſtirred or ſhaken by the blind ſlaves, and ſeparate the part that ariſes to the ſurface, as they conſider it more valuable and delicious than that which is below it." Hippocrates, who was nearly the contemporary of Herodotus, mentions the ſame, but in a much clearer manner.

"The Scythians pour the milk of their mares into wooden veſſels, and ſhake it violently; this cauſes it to foam, and the fat part which is light riſing to the ſurface, becomes what is called butter; the heavy and thick part which is below, being kneaded, and properly prepared, is after being dried called *hippace*. The whey or ſerum remains in the middle." This paſſage, it would ſeem, denotes very clearly butter, cheeſe, and whey. Hippocrates preſcribed it as a medicine under the name of *pikerion*, which becoming obſolete is tranſlated by Galen, *butyron*. The word does not occur in Ariſtotle. In Dioſcorides, we are informed that freſh butter might be melted and poured over pulſe and vegetables inſtead of oil, and employed in paſtry inſtead of other fat ſubſtances. Galen remarks, that cows milk produces the fatteſt butter; that of the goat or ſheep is leſs rich, and that of the aſs yields the pooreſt. Hence butter muſt have been very little uſed or known by the Greeks or Romans in the time of Galen, *i. e.* at the end of the ſecond century. According to Galen and Pliny, the word βȣτυϱος or βȣτυϱον is compoſed of βȣς an ox and τυϱος cheeſe; cheeſe was known to them much earlier, and perhaps they may have looked at firſt upon butter as a kind of cheeſe, as τυϱος once ſignified, according to Bechmann, any coagulated ſubſtance. The Greeks uſed the milk of ſheep and goats much earlier than cows milk. From what has been ſaid, as well as from other documents, it appears, that butter is neither a Grecian nor a Roman diſcovery, but that the Greeks were made acquainted with it by the Scythians, the Thracians, and the Phrygians; and that the Romans firſt learned it from the people of Germany. It is alſo pretty certain, that when they had been taught the art of making it, it was only employed in their baths, and particularly in medicine; and it may be obſerved, that Columella is the firſt Latin author who uſes the word *butyrum*. The Romans uſed it in general to anoint the bodies of their children, and the ancient Burgundians beſmeared their hair with it. Neither the Greeks nor the

Romans uſed it in cookery, or the preparation of food; they accuſtomed themſelves merely to oil, and even at preſent, it is rarely employed in Italy, Spain, Portugal, and the ſouthern parts of France, where it is ſold in the apothecaries ſhops for medicinal purpoſes. We may therefore conclude, that the ancients were unacquainted with the method of kneading, waſhing, and ſalting butter, in order to render it as firm as it is now a days. It was always in an oily ſtate and fluid, they always ſpeak of ſomething liquid; thus the ancients poured it out like oil, and their elephants drank it; but the moderns cut, knead and ſpread it.

Cheeſe and Whey.

With reſpect to cheeſe and whey, we are informed, that cheeſe was prepared even from the moſt ancient times in Syria, Paleſtine, and Egypt, from the milks of the cow, the camel, the goat and the ſheep; and that it was a food particularly delightful to the Scythians, and the Greeks; and not only Hippocrates, as before mentioned, but many of the ancients clearly deſcribe the ſeroſity of milk or whey; amongſt which are Columella and Dioſcorides; they deſcribe the method of ſeparating it by agitation, by coction, or by mixing with the milk vinegar, or the branches of the fig tree; and they likewiſe give ſome account of what they called *oxigala*, which is a preparation formed by the addition of ſome ſalt or more ſimply by the mixture of ſour with freſh milk. In the time, however, of Pliny, it appears, that ſome of the barbarous nations living on milk were either ignorant of the benefit of cheeſe, or if it was known to them, they diſregarded it. Pliny ſeems to have looked upon this with aſtoniſhment, for at the ſame time, they were accuſtomed to thicken their milk into a ſort of pleaſant ſour curd like a ſyllabub, and as he expreſſes himſelf, to churn butter from it, which is the ſcum and cream of milk, and much thicker in conſiſtence than the whey. We are informed by this celebrated Roman author and natural hiſtorian, that the milk which is afforded by thoſe animals that have teeth in both jaws is not fit to make cheeſe, becauſe it will not curdle. This has been certified by the beſt chemiſts of modern days with reſpect to that of the human female, which is in general found incapable of coagulation, although it has been denied by others. Pliny likewiſe informs us that the milk of the cow affords more cheeſe than that of the goat, being nearly twice as much; and that at Rome, the beſt cheeſes came from the provinces of Nemauſium, and from the villages of Læſo and Baux, but that it was neceſſary to eat them green. Excellent cheeſe was likewiſe made in Dalmatia, Drinaldi, and Vatuſium, in the province of Ceutonia, and in the Sæditian territory. In his days, the beſt foreign cheeſe came from Bithynia, whilſt that ſent from France had a phyſicky taſte and a kind of aromatic ſavour. With reſpect to any other knowledge the ancients had of the other component parts of this fluid, it was perhaps only a ſuperficial acquaintance with the ſaccharine part, and limited to the organs of taſte.

State of analyſis of milk in the middle of the laſt century.

The analyſis of milk ſeems to have been but very imperfectly underſtood towards the middle of the laſt century. Swammerdam and Leuwenhoeck had examined it's globules by the microſcope; it was known that warmth aſſiſted in it's coagulation, and that in tempeſtuous weather it became ſour much ſooner than in calm ſeaſons; that this took place more readily in ruminating than non-ruminating animals, and that the milk of the carnivorous claſs, when fed entirely on fleſh, was not coagulated at all. Homberg, Boerhaave, du Hamel, Rutty, Navier, Egeling, Geymuller, and Wulliamoz, had made ſome obſervations and a few experiments upon it; it's coagulation by acids, by alcohol, by alum, was known; the ſpecific gravity of the different milks had been examined, the quantities of the cream, butter, and cheeſe they contained, in ſome meaſure aſcertained; it had been ſubjected to the power of caloric, and from it, on diſtillation, we are informed, much water was obtained; this was rather empyreumatic, an acid ſpirit afterwards, a fetid oil, and a ſplendid friable coal remained at laſt, in which was a fixed ſalt. Butter and cheeſe had likewiſe undergone a ſlight examination; an acid water with the butyraceous odour, a thick fluid oil, and another kind that was tenacious and red, were ſaid to have been produced from the firſt, and on the incineration of the coal, a fixed alkali was obtained which was ſuppoſed to be the vegetable; the ſecond, or caſeous part, was ſaid to be of a mucilaginous nature, that it gives an acid phlegm, a bluiſh oil, ſomewhat empyreumatic, then thick, black, and ſo weighty as to ſink in water, and that the coal is afterward difficult of incineration. It was thought that the caſeous part was the moſt powerfully nouriſhing of the milk; that the oily or butyraceous part had a laxative property, and that the aqueous part was of a refrigerating nature; with reſpect to the ſerum of milk, or it's whey, it had been long known that it contained a ſaccharine part, which was ſaid to be of an animal nature. This had been firſt mentioned by Fabricius Bartolettus, and afterward deſcribed by Lewis Jeſti, though the Brachmans had been before accuſtomed to procure it from milk, as well as other ſweet juices. Navier had extracted it from the human milk, and Hoffmann from that of the aſs.

Very ſoon after this period, more numerous experiments were made to procure a more exact analyſis of milk; it's phyſical properties were better defined, and the action of reagents on different ſpecies of it, were more ſucceeſsfully inveſtigated by Geoffroy, Bergius, Voltelen, Spielmann, Scheele, &c. a few of which it will be neceſſary to mention, without going into any extenſive detail. With reſpect to the quantities of cream, cheeſe, whey, and the butyraceous parts of different milks, Spielmann has examined thoſe of the human, the Spielmann. goat, the ſheep, and the cow; he informs us, that two pounds of the firſt contained one ounce and a half of cream, which afforded ſix drachms of butter, half an ounce of a tender cheeſe, and ten drachms of a fixed matter which remained after inſpiſſation of the whey; the reſt was water. From the ſame quantity of the milk of the goat, he obtained one ounce of cream, three drachms of butter, three ounces and three drachms of cheeſe, and ſix drachms of a fixed matter; hence it contained more cheeſe, and leſs water and oil than the human. The ſame quantity of ſheep's milk afforded him two ounces of cream, fourteen drachms of ſoft butter, four ounces of cheeſe, and ten drachms of fixed matter; hence he found it to be fatter and more caſeous than the human, but not ſo thin. From the ſame quantity of cows milk he procured three ounces and half of cream, ſix drachms of hardiſh butter, three ounces of cheeſe, eleven drachms of fixed matter; hence it exceeded the human by far, both in butter and cheeſe. He found the milk of the aſs to be the heavieſt, and that of the goat the lighteſt.

According to Voltelen's experiments, thirty ounces Voltelen. of human milk afforded him only two drachms of cream. The ſame quantity of aſſes milk gave him only three drachms of cream, but no butter, three drachms of tender cheeſe, an ounce and half of a fixed matter on inſpiſſation; and he found it contained more fixed part and water, and to be leſs rich in butter and cheſe than the human milk. Two pounds of mare's milk afforded three drachms of cream, no butter, ſeventeen drachms of cheeſe, and nine of fixed matter; which is, therefore, richer in the laſt matter, but contains leſs oil and water than the human milk.

With reſpect to the ſpontaneous acidity of milk, that of the human, which is ſaid to afford more cream in a ſhorter time than any other, is not ſubject to this fermentation, if the perſon has been accuſtomed to fleſh diet; for, according to Bergius, ſome of it, after having been placed in a heated oven for many weeks, and being covered with a very thick cream, had contracted not the ſlighteſt acidity. On the contrary, we are informed, that when the perſon fed only on a vegetable diet, it coagulated on the eighth day, whilſt that of the cow becomes acid in three days and a half. Bergius.

With reſpect to the coagulation of milk by *acids*, according to Voltelen, the three mineral acids, as well as aqua regia and vinegar, ſoon coagulate ſheep's milk in the cold; but cream of tartar coagulates it more ſlowly. He found that aſſes milk is coagulated by vinegar, cream of tartar, ſpirit of ſulphur, aqua regia, nitrous and vitriolic acids, in the cold; and that rennet from the calf, and ſmoking muriatic acid, required the aſſiſtance of heat: that human milk was neither coagulated at it's natural temperature, nor in the cold, by lemon juice, cream of tartar, rennet, ſpirit of vitriol, nor by the three ſtrong mineral acids; on the contrary, in a boiling heat, a yellow porous coagulum was ſeparated from it by the nitrous acid, and a thick white one by the muriatic; the firſt of which, on digeſtion with nitrous acid, became of a bluiſh and bluiſh-grey colour; the other remained unchanged; whilſt, according to Bergius, it became coagulable by vinegar, after the perſon had lived on vegetable diet, which muſt be continued at leaſt eight days. According to Scheele, the Acids.

vegetable acids produce more cheeſe from cow's milk than the mineral.

Scopoli obtained from one ounce of cow's milk, coagulated by vitriolic acid, ſeventy grains of reddiſh coagulum, and on filtration, a perfectly tranſparent whey; with muriatic acid, 51 grains of the firſt, and the whey not quite ſo tranſparent; with nitrous acid, 46 grains of yellow coagulum and turbid whey; with acid of arſenic, 61 grains of whitiſh coagulum, and the whey evidently tranſparent; with fluor acid, 40 grains of the ſame, and a ſimilar whey, which, however, depoſited a yellow coagulum; with phoſphoric acid, 40 grains of white coagulum, and ſome clear whey, from which a little more coagulum fell to the bottom; with acid of ſugar, 43 grains of whitiſh coagulum and turbid whey, which ſtill depoſited ſome coagulum; with acid of tartar, 48 grains of the ſame, without ſediment; with animal acid, 25 grains of the ſame, which on repoſe depoſited more; with the acid of wood, 28 grains of whitiſh coagulum, and turbid whey; with vinegar 36 grains of reddiſh coagulum, and clear whey, with ſome little coagulated depoſit; and laſtly, with lemon acid, 40 grains of yellowiſh coagulum and turbid whey, from which ſome more coagulum ſeparated.

Alkalis. With reſpect to *alkalis*, we are informed by Egeling, that cow's milk is coagulated either by fixed or volatile alkalis.

Scopoli obtained from one ounce of cow's milk mixed with mild vegetable alkali, forty-eight grains of white coagulum and turbid whey; with cauſtic volatile alkali, forty-ſix grains of yellowiſh coagulum and turbid milk, which, after filtration, ſeparated more coagulum; and with mild volatile alkali twenty-four grains of white coagulum and turbid whey. According to Morgagni, lime water does not coagulate cow's milk. According to Voltelen, ſheep's milk is not coagulated by cauſtic volatile alkali; by cauſtic fixed alkalis and lixivium ſanguinis only by heat; but by common, fixed, and volatile alkalis, light flocks are produced in it; and by a boiling heat, larger flocks. Mixed with lime water, both in heat and cold, it remains unchanged. From aſſes milk, cauſtic volatile alkaline ſpirit, produced only extremely ſmall flocks; the common volatile alkali in the cold, ſomewhat larger; ſoap lees had a leſs effect; lixivium ſanguinis, and much ſooner common alkali, afforded thick lumps of coagulum; lime-water had no action upon it, but by no means prevented it's coagulation by acids and rennet.

According to Bergius, the human milk was neither changed in it's natural temperament, nor at a boiling heat by ſpirits of hartſhorn, volatile alkali, nor by ſpirit of ſal ammoniac; nor by oil of tartar, or fixed alkali, either in it's common temperature or in the cold; mixed, however, with it at a boiling heat, and digeſted, they changed it's colour to a yellowiſh green, which gave immediate riſe to a thick pellicle, and an odour of ſweet cheeſe. Nor was this milk changed by ſoap lees in the warmth, from Voltelen's experiment; but lixiv. ſang. although it did not coagulate in the cold, yet by a boiling heat produced a ſtrong coagulation, with an evident change of colour. By the ſame heat it was coagulated by lime water. We likewiſe are informed by Voltelen, that the human milk, the ſheep's, and the aſſes milk, and the cows milk, according to Boerhaave, on being boiled with fixed alkalis, become by degrees more yellow, afterwards reddiſh, and at laſt blood-coloured, brown red, and dark red. After ſome time ſmall flocks are ſeparated from this red fluid, which is covered with cream, and this takes place immediately if vitriolic acid be added. The human milk, when boiled with lixiv. ſang.

depoſits a caſeous matter in forty-eight hours, whilſt a yellowiſh red tough pellicle is formed on it's ſurface, and the fluid itſelf is darkiſh. According to Silvius's conjecture, it was by ſuch means that the converſion of chyle into blood was brought about.

Neutral.

According to Voltelen, the human, cows, ſheep's, and aſſes milk, neither in the cold nor by heat, are acted upon by ſolutions of ſaline neutral ſalts, ſuch as vitriolated tartar, nitre, common ſalt, ſal ammon. ſpiritus, Minder. nor by borax. It, however, appears, that ſal ammon. promotes the ſeparation of the cream and whey in the milk of the ſheep, and that common ſalt coagulates milk, although Gourraigne affirms, that it prevents the coagulation of it by acids. With reſpect to the earthy neutral ſalts, bitter ſalt has no effect upon milk. According to Voltelen, alum has no effect on human milk, either in the cold, or with the aſſiſtance of heat; but decompoſes that of the aſs and the ſheep when boiled with it.

Metallic ſolutions.

The ſame chemiſt informs us, that moſt of the metallic ſolutions decompoſe the different ſorts of milk, in a longer or ſhorter ſpace of time: that ſolutions of iron and it's vitriol act upon them in the cold: that ſugar of lead, which decompoſes aſſes and ſheep's milk immediately in the cold, appears only to haſten the ſeparation of the cream in the human milk: that the vitriolic and nitrous ſolutions of quickſilver produce a quick coagulation and a red colour. The ſolution of corroſive ſublimate coagulates them in the warmth. The acid ſolution of copper, decompoſes aſſes and ſheep's milk, but only colours human milk, and the volatile alkaline ſolution of copper has no effect in coagulating milk of any ſpecies. A ſolution of ſilver coagulates milk, and colours the whey, firſt of a roſe colour, then of a purple red. We are informed by Navier, that arſenic appears to prevent the coagulation of milk. Voltelen likewiſe informs us, that aſſes milk was not coagulated by the mercurius gummoſus of Plenck, in the cold, but was very ſtrongly ſo by the aſſiſtance of heat; this, however, is ſuppoſed to have ariſen from the gum, which, according to Scheele, as well as the albumen of the egg and ſugar, coagulates milk.

Alcohol.

According to Leonhardi, the human milk mixed with alcohol, at firſt did not coagulate, but began in about twenty-four hours, by the means of heat. The alcohol had no effect on the milk, when ſedative ſalt or camphor was diſſolved in it; on the contrary, the alcohol coagulated aſſes milk a little in the cold, and ſheep's milk very ſtrongly. With ſpiritus camphori, both the kinds of milk undergo no change; camphor even appeared to prevent their coagulation.

Scopoli obtained by alcohol, twenty-five grains of white coagulum, and the filtrated whey was afterwards milk white.

The aſtringent vegetables decompoſe in the cold, the human milk, and thoſe of the cow, the aſs, and ſheep. According to Scheele, the ſame effect takes place with the Peruvian bark. According to Bergius, human milk is neither coagulated by ſaliva, nor bile, nor by the white of eggs.

Coagulation of milk.

With reſpect to the beſt methods of coagulating milk, ſo as to procure the whey as pure as poſſible, we are informed by Frederick Hoffmann, that ſour whey, (ſerum lactis acidulum) is procured by adding one drachm of cream of tartar, or one or two tea-ſpoonfuls of lemon juice to one pound of boiling milk, and to keep it boiling afterwards until the caſeous part is perfectly ſeparated. It is then to be clarified with the white of eggs, filtrated, and edulcorated by the powder of crabs-eyes.

Vinous milk (ſerum lactis vinoſum) is prepared by adding four or ſix ounces of good ſour white wine to a meaſure of boiling milk, and after coagulation filtrating the liquor.

Another kind of whey, called *doppelmolken* by the Germans, (ſerum lactis duplicatum) is obtained by equal parts of freſh milk and butter milk, being mixed together when warm.

According to Pœrner, it is much better for the cheeſe and the whey, to coagulate milk by rennet; by this means he obtained the beſt and ſweeteſt whey, and it afforded a greater quantity in general, than when cream of tartar or lemon juice was uſed. If either of the laſt ſubſtances be employed, it is neceſſary to add crabs eyes, or a ſimilar ſubſtance, to the ſour whey obtained, to edulcorate it, which give it an unpleaſant earthy taſte. Beſides, ſome part is diſſolved by the acid which remains after filtration. Pœrner, therefore, gives the preference to rennet, which may be prepared in different manners, of which he mentions two. The ſtomach of a ſucking calf being blown up whilſt the coagulated milk remains in it, it is gradually dried; the two ends are then to be cut off, the coagulated milk, which is nearly dried, muſt be thrown away, and only the ſtomach employed, of which a piece about a finger's length is to be cut off when required, put into a glaſs, and three or four ſpoonfuls of freſh water added to it, in which it is to remain from ſixteen to twenty-four hours. A ſpoonful of this is then to be taken, and mixed with a kanne of the ſkimmed milk to be coagulated; it is then placed on a moderate fire, ſo as to be made warm until it is coagulated, which takes place in a quarter, or at fartheſt half an hour. It is then to be filtrated, and the whey is very pleaſant and not acid. The other method is to take the freſh ſtomach of a ſucking calf, cleanſe it, put the coagulated milk in again, add a little common ſalt, and fill the ſtomach half full of milk. Having tied the two ends, it is to be placed in a baſin and more milk added to it, a little more ſalt added, and to be left to repoſe a couple of days in a moderately warm place; which, according to Leonhardi, ought to be from 70° to 100° of Fahrenheit. Of the milk which has now become coagulated in the baſin, a ſpoonful is to be taken and uſed as before mentioned. When this is conſumed, the ſtomach is to be opened to let a little run out, tied again, and the baſin filled as before with milk, and covered. By this means a ſtomach will laſt nearly a year; care muſt, however, be taken that it become not putrid. Hence it appears, that Pœrner, as well as Macquer, was of opinion that the coagulation proceeded from the coagulated milk of the ſtomach, and that the cauſe of this was an acid. It is ſcarcely neceſſary to mention, that the coagulation is now well known to be cauſed by the gaſtric juice, and that the ſtomach is uſed in a dry ſtate.

According to Macquer, whey is not only the aqueous part of the milk, but contains likewiſe all the component parts of it which are ſoluble in water. It has a peculiar taſte, which becomes ſtronger on evaporation. This ſavour is ſomewhat ſaccharine and ſaline. It contains an extractive ſaccharine matter, and hence is capable of the ſpirituous fermentation. It alſo contains other kinds of ſalts, which are mentioned by Leonhardi, ſuch as the vegetable alkali, the acid of milk, phoſphat of lime, and digeſtive ſalt.

Diſtillation of milk.

According to Boerhaave, the water which comes out on the diſtillation of milk is ſomewhat empyreumatic and nauſeating to the taſte. Voltelen found this water of the ſame ſmell as the milk, and mild in ſavour, but unpleaſant. Beſides this water which he obtained from the diſtillation of the human, aſſes, and ſheep's milk he obtained an acid ſpirit, a light and heavy oil; and in the aſſes, after incinerating the coal, a fixed alkaline ſalt, a ſort of neutral common ſalt, an earthy ſubſtance, and ſome particles of iron. He likewiſe obſerved in the diſtillation of the milks of the aſs and ſheep, that a real volatile alkali aroſe after the acid ſpirit. Beccaria had obſerved the preſence of this alkali in milk, and Hahn had obſerved it in that of the cow; but in Voltelen's experiments, there were no traces of it in the human milk. From the laſt milk, however, there was extricated a very large quantity of an elaſtic gaſeous matter even during the coming over of the water, which at times threatened to break the veſſel, of this air he did not find any in the two other milks.

Sugar of milk.

Bartholdi.

It is related by Kempfer, that the Brachmans were acquainted with the proceſs of making the ſugar of milk: whether this was the caſe or not, Fabricius Bartholdi, an Italian phyſician, is the firſt who has mentioned this eſſential ſaccharine ſubſtance of milk in his Encyclopædia, printed at Bologna in 1619, under the title of Manna; or Nitre of Milk: and it is from this book that Etmuller has borrowed his deſcription of it. In 1698, Teſti, a Venetian phyſician, publiſhed a Memoir of the Sugar of Milk, in which he appears to attribute the diſcovery of it to himſelf: he ſpeaks with great zeal of it's medical virtues, particularly in the cure of the gout, and in an alchemical ſtyle deſcribes the method of preparing it. Different accounts of the ſame ſort have been given by Werloſchnigg, Valliſnieri, Fickius and Cartheuſer. We are informed by Wulliamoz, that the manner in which Cartheuſer prepared it did not ſucceed with him; he praiſes in the higheſt ſtyle the ſugar of milk prepared by one Creuzius, and eſteems it the beſt mode of any which the Swiſs make uſe of, and which he regrets is not underſtood elſewhere. It is known that in Switzerland this ſugar has long been made a part of their traffic; they

Teſti.

Wulliamoz.

ſell two ſorts of it, one in the form of tablets, the other in that of cryſtals. He has given us the method employed in the Alps for making both varieties. For the firſt, the milk muſt be previouſly ſkimmed, it is then coagulated by rennet, filtrated through a linen cloth, and the whey evaporated over a ſlow fire to the conſiſtence of honey; when it is ſufficiently thickened, it is put into moulds of different figures and dried in the ſun. For the ſecond, theſe tablets are diſſolved in water, clarified with the white of eggs, then filtrated and evaporated to the conſiſtence of ſyrup, and left in repoſe to cryſtallize. Theſe cryſtals, on examination, are found to be compoſed of cubic maſſes, very brilliant and white, and are attached to the ſides of the veſſel in ſtrata; if the remaining liquor be again expoſed to heat, and evaporated, other cryſtals are obtained on evaporation, and this operation may be ſeparated a third time. The firſt cryſtals are of a dazzling white, the ſecond of the colour of ſtraw, and the laſt of a bran colour; theſe by ſolution, clarification, filtration, and cryſtallization, may be brought to the ſame dazzling whiteneſs and degree of purity as the firſt. According to Wulliamoz, the properties which he found the ſugar of milk to poſſeſs, and the products it afforded him on decompoſition, prove it to be of a ſaponaceous nature; it unites oils with water, and it has a great reſemblance to the juice of the ſugar cane.

Haller has, according to Morveau, given the beſt method of preparing the ſugar of milk. The whey is to be clarified with the whites of eggs, and continually kept boiling until that part is ſeparated, in order to thicken it before it has contracted any acidity. The cryſtals are then neither acid nor alcaline, but an eſſential ſalt as perfect as the ſugar of the cane, which like it renders oils miſcible with water, prevents the cream ſeparating from the milk, and in ſhort has the properties of ſoap. Haller

Haller,

believes that the milk of all animals contains this ſalt, but not in the ſame proportions. According to his account, four ounces of ſheep's milk afforded from 35 to 37 gr. of ſugar.

Goats	47—49
Cows	53—54
Human	58—67
Mares	69—70
Aſſes	80—82

Lichtenſtein.

Lichtenſtein has examined and analyſed the different ſugars of milk, which are ſold at various prices in Switzerland, and has more particularly diſtinguiſhed ſix ſpecies, of which an account will be given. He extracted this ſugar both from ſweet and ſour whey; he found that the reſidue of the ſaccharine cryſtallization, or what remains after the cryſtallization of the ſugar of milk in *ſweet* whey, is pituitous, ſomewhat empyreumatic, and taſtes ſaline; that it is eaſily diſſolved in water, changes the ſyrup of violets, tincture of litmus, and the ſolution of Brunſwick, green. When mixed with liver of ſulphur, no ſtrong ſmell ariſes; rubbed with fixed alkalies, unſlacked lime or minium, it gives a volatile alkaline ſmell; and mixed with vitriolic acid, a ſmell of muriatic acid; it gives a precipitate of luna cornea when mixed with the ſolution of ſilver; and plumbum corneum and a white precipitate in the ſolutions of lead and mercury. On digeſtion with ſpirit of wine, and then mixing with vitriolic acid, there ariſes a fine acid ſmell; but mixed with fixed alkali, a volatile alkaline ſmell. The gelatinous reſidue from *ſour whey*, in which the acid ſugar of milk has cryſtallized, is according to the ſame author ſouriſh, and likewiſe ſomewhat alkaline to the taſte; it colours the ſyrup of violets and tincture of litmus red, effervеſces with common alkalis, colours the blue ſolution of Brunſwick green immediately of an emerald green; decompoſes liver of ſulphur with the common diſagreeable ſmell;

communicates to alcohol digeſted with it a yellow colour, and after the evaporation of the alcohol, there remains a brown, pituitous, ſaline, ſour taſting ſubſtance, which effervesces with fixed alkalis, emitting a volatile alkaline ſmell, and with the vitriolic acid, an acid ſmell. What the alcohol will not diſſolve does not effervesce with alkalis, gives no acid ſmell with the vitriolic acid, and depoſits after ſolution in water a light yellowiſh earth.

Clarified ſweet ſugar of milk (ſaccharum lactis puriſſimum) which is cryſtallized from ſweet whey, according to Lichtenſtein, is of a milk white colour, conſiſts of ſmall cryſtals which are ſemitranſparent, forming regular parallelopiped priſms, terminated by a regular pyramid parallelogramically rectangular, which at the temperature of 10° or 11° of Reaumur has a ſpecific gravity of 1.543.

Water at the ſame degree diſſolves about the 7th of it's weight.

It is inſoluble in rectified ſpirit of wine.

It's flavour is rather ſweetiſh, it has no ſmell.

It does not change the colour of turnſole, or ſyrup of violets, or the ſolution of Brunſwick green; it does not render turbid the ſolution of corroſive ſublimate, nor decompoſe the calcareous hepar of ſulphur. When pulveriſed with potaſh, lime, or minium, it gives out no ammoniacal odour, nor does the vitriolic acid diſengage from it any vapour of the muriatic acid.

It does not decompoſe the ſolutions of ſilver, lead, or mercury.

It is completely ſoluble in the nitrous acid; after evaporation, a fermenting maſs is found, which, on being dried and burnt, ſhows the ſame properties as the pure ſugar of milk.

Expoſed to a gentle fire in an earthen veſſel, there ariſes an odour of burnt ſugar, it ſwells conſiderably, and becomes a black thick maſs, which at firſt hardens in the air, but afterwards becomes ſoft, and when applied to the tongue taſtes ſweetiſh like the ſugar of milk itſelf, and leaves a moderately bitter ſavour in the mouth. In a ſtronger heat, it burns to a black ſpungy coal, which exhales an odour of burnt tartar.

The ſugar from ſour whey (ſaccharum lactis aceſcens) is the ſugar of milk mixed with galactic acid. It is of a yellowiſh colour, in ſmall cryſtals; it's ſavour agreeably acid, and it's aroma fatty and acidulous.

It is more readily diſſolved in water than that from ſweet whey.

It efferveſces with alkaline and earthy ſubſtances, by which it loſes it's acidity.

It reddens the ſyrup of violets, and the infuſion of litmus, and deſtroys the blue ſhade of the Brunſwick green.

It colours yellow, rectified alcohol, and this as it evaporates takes away all it's acidity; water itſelf extracted from it ſeveral times does the ſame. It precipitates the hepar of ſulphur, with a ſtrong hepatic aroma.

The fire acts upon it as on pure ſugar of milk.

Lichtenſtein likewiſe deſcribes a ſugar of milk united with oily particles, and it is this which ſhoots during the firſt cryſtallization. It appears of a yellow colour, and becomes rancid in time; when, however, deprived of the oily parts, it is real pure ſugar of milk. He likewiſe mentions another ſugar united with an oil and common ſalt, and which is of the laſt cryſtallization. It is of a yellow colour, ſaline ſavour, gives a muriatic acid odour on adding the vitriolic acid to it, precipitates ſilver, lead, and mercury white from their ſolutions in nitrous acid, and in time becomes rancid. He mentions a third ſugar united with oil, common ſalt, and ſal ammoniac, which, beſides the foregoing properties, poſſeſſes that of feeling conſtantly pituitous and moiſt, and affords a volatile alkaline ſmell, on being rubbed with fixed alkalis; and laſtly, another ſugar which beſides being united with oil, common ſalt, and ammoniac, is found tainted with a mucus or a caſeous part, which is not fixed and cryſtallized, but mealy, becoming in time mouldy and rancid, and depoſiting a caſeous matter on it's ſolution in water. This is the moſt imperfect ſort of the ſugar of milk. An acid is likewiſe to be found united with all theſe impure kinds, when they are prepared from ſour whey.

Repeated ſolutions and evaporations of ſugar of milk by a ſtrong heat decompoſe it in part; it ſcarcely preſerves it's ſweetiſh taſte, but has an earthy and diſagreeable ſavour. It very difficultly diſſolves in water; it has the appearance of chalk, and when mixed with an alkali, it depoſits much more earth than pure ſugar of milk.

To purify ſuch impure ſugars, either chalk, calcareous marl, or ſpirit of wine may be employed.

Leonhardi.

Leonhardi was informed by his friend Geutler, an apothecary in Switzerland, that the peaſants there made uſe of alum, which they bought in large quantities, to coagulate their milk with, and by which they obtained very white ſugar of the firſt cryſtallization; whilſt Prince, an apothecary at Neuchatel, who prepares by unknown means a beautiful ſugar of milk, without the medium of any foreign ſubſtance, entirely rejects this addition.

When this ſugar of milk is perfectly pure, it is quite white, and nearly taſteleſs.

Rouelle.

Rouelle, who has made many experiments on the ſaccharine part of milk, agrees very much with thoſe of Lichtenſtein, reſpecting the ſugar obtained from ſweet whey. In his paper publiſhed in the Journal de Médecine for March 1773, he has given the following account of them.

Whey obtained without cream of tartar affords on evaporation to the conſiſtence of a ſyrup, and placed in cold, cryſtals of the ſalt or ſugar of milk. This mother ley, he informs us, may be evaporated to the third time, and freſh cryſtals obtained; but it then contains ſome cryſtals of digeſtive ſalt of Sylvius. The remaining ley or rather coloured liquor, conſiſting of the mucous part, is changed ſometimes by means of the mucus into a jelly; it alſo contains an extractive matter. This ley, mixed with twice it's quantity of diſtilled water, had no effect on the ſyrup of violets; nor did a diluted acid effervefce with it.

If concentrated vitriolic acid effervefced ſomewhat with the laſt cryſtallization, or it's ley, there aroſe ſome muriatic acid vapours, which Rouelle attributed to the ſalt of Sylvius.

The ſugar of milk on diſtillation afforded, 1ſt. a little phlegm, 2d. an acid, 3d. an oil, 4th. a large coaly matter remained, reſembling that from the diſtillation of ſaccharine mucous bodies, as honey, manna, ſugar candy, &c. It had no fixed alkaline properties, nor did it effervefce with acids as the coal of tartar does. It afforded ſcarcely any aſhes on incineration, which were ſtill black, and hence contained undecompoſed coal. United with water, it changed the ſyrup of violets green; and did not, however, effervefce with acids: but Rouelle thinks it contained an uncommonly ſmall quantity of fixed alkali; conſequently the products of this ſugar are the ſame as thoſe of ſtarch and ſugar candy, a very few circumſtances excepted.

The laſt cryſtallization, and it's mother ley, afforded by the lixiviation of their coals a little digeſtive ſalt of Sylvius, and a very ſmall quantity of fixed alkali, which appeared to Rouelle to proceed from the extractive matter.

The ſugar expoſed to a ſtrong heat in an iron kettle melted in part, and was of the colour of burned ſugar.

(caramel): the ſmell was that of burnt honey, manna, or common ſugar. He found two parts of ſugar candy to require one of water for ſolution; and for the ſolution of the ſugar of milk, ſcarcely more than an equal quantity was neceſſary. The ſalt from the incineration of the coal of cows milk afforded him fixed vegetable alkali; the reſt was the ſalt of Sylvius; for being decompoſed by the vitriolic acid, the muriatic acid was ſeparated, and vitriolated tartar obtained. By the nitrous acid he obtained nitre. He found ſix grains and half of alkali in one pint of milk.

From the experiments of Beaume, it appears, that from the third cryſtallization, he obtained cryſtals of common ſalt, and from the mother ley, which produced no more ſugar, he procured a fixed alkali without incineration. He obtained the laſt alſo after the diſtillation of the ſugar. It remained in the retort, and he found this ſugar of milk to have many properties in common with cream of tartar, excepting it's not being ſour. According to Beaume, the whey of the milk of the cow, evaporated to three fourths, affords the ſugar of milk. Beaume.

The ſtrongeſt acids had no effect upon it, at the ſame time he looks upon it to be of a ſaponaceous nature. On expoſure to fire in a retort, he obtained empyreumatic oil, and a fixed alkali remained.

By a ſecond evaporation, he obtained a ſalt reſembling the firſt, which was, however, decompoſed by the mineral acids. The third evaporation of the whey afforded cryſtals of common ſalt.

A fluid remained, incapable of affording more cryſtals, it contained fixed alkali and a little extractive matter, the alkali he obtained without incineration.

Each pint of whey afforded ſeven or eight drachms of theſe ſalts, the origin of which Beaume attributes to the vegetable nouriſhment of the cow.

It appears from the experiments of the two laſt French chemiſts, that in their examination, they attended more to the reſiduum of the evaporation, than to the action of reagents on the ſugar of milk. For a more exact analyſis of it, we are indebted to Scheele and Hermbſtadt, which will clear up any doubts reſpecting it's component parts.

Scheele. Scheele's Memoir on this ſubject was publiſhed in 1780, in Sweden. In this diſſertation, the ingenious chemiſt proves that the ſugar of milk affords the ſame products as any other ſugar; but the moſt remarkable is, that the empyreumatic oil has an aroma approaching that of the benzoic acid, or ſalt of benzoin. By diſtillation with the nitrous acid diluted, he procured real ſaccharine acid as in common ſugar; but from this experiment he was conducted to the diſcovery of the *ſaccholactic acid*; for on treating the ſugar in the ſame way as that for obtaining the ſaccharine acid from common ſugar, he found a quantity of white powder, which troubled the ſolution, and which he got upon the filter on filtrating the ſolution, previous to it's exſiccation to obtain the cryſtals of the ſaccharine acid. The quintal afforded him fifteen pounds and half of ſaccharine acid; and twenty-three pounds and half of the white powder.

Hermbſtadt This memoir of Scheele, it appears, had not reached Hermbſtadt, when the latter publiſhed, in 1782, his examination of this ſalt and it's acid. He did not uſe the fuming nitrous acid, but preferred the double aqua fortis, ſimply rectified on the nitre, and from which he had ſeparated the more aqueous particles that firſt ariſe. Having extracted it, he found in the retort when cooled a depoſit of a conſiderable quantity of earthy matter, and the ſurface covered with a pellicle of the ſame nature; beſides this, he obtained real ſaccharine acid. With four parts of the ſugar of milk, and twenty-ſix of nitrous acid of 1,320 ſpecific gravity, he obtained out of the quintal only fourteen and one ſixteenth of the acid of ſugar, and forty-three and three fourths of the above mentioned white powder. It may be remarked, that the aqueous ſolution of the ſugar of milk mixes with vitriolic acid as well as mild vegetable alkalis, without affording any depoſit. On diſtillation, he obtained from two ounces of the ſugar of milk ſome very thick white vapours, ſix drachms of a clear yellow, ſtrong, and empyreumatic acid fluid; a few drops of a dark red oil, and ſix drachms of coal; which, on expoſure to a red heat, loſt two ſcruples; and from which ſolution in mineral acids he precipitated with mild vegetable alkali a little calcareous earth.

From the experiments, therefore, of theſe two chemiſts, it appears, that the ſugar of milk well prepared and rectified contains no diſengaged acid or alkali, or mineral neutral ſalt; that it's eſſential conſtituent parts are, 1ſt. a real ſugar like that of the cane, *i. e.* the radical of the ſaccharine acid united to the ſyrupous acid which exiſts perfectly formed; 2d. another ſubſtance of an earthy appearance, and which modifies the exterior characters of the ordinary ſugar.

EXAMINATION OF THE DIFFERENT KINDS OF MILK.

Six different ſpecies of milk examined.

The different kinds of milk that have undergone the inveſtigation of ſeveral of the beſt chemiſts of the preſent time, and upon which ſome very curious and inſtructive obſervations have been made, are ſix in number, viz. the milk of the cow, the human milk, thoſe of the aſs, the goat, the ſheep, and the mare. But although much has been done in order to gain a complete knowledge of their component parts, and of the cauſes that conſtitute their differences; yet there are many circumſtances attending each ſpecies, which future experiment and obſervation muſt unfold.

Milk of the cow.

Milk of the cow. Since this is the moſt univerſal of any, not only when uſed crude as an aliment, but for a variety of culinary purpoſes, it is not extraordinary that it ſhould have been oftener the ſubject of analyſis; and we have, perhaps, a more exact account of it's nature, properties, and contents, than thoſe of all the others put together. It has been more particularly examined of late by the French chemiſts, from whoſe labours this, as well as the other parts of the ſame ſubject, will be for the moſt part extracted.

Colour, ſmell, and taſte.

The milk of the cow, when firſt drawn, is a white opake fluid, it has a peculiar pleaſant ſmell, is of a ſweetiſh, ſomewhat fattiſh taſte; but theſe properties depend upon a variety of circumſtances, ſuch as the peculiar temperament, food of the animal, &c. Thus immediately after calving, it partakes more of the animal nature, and it receives a diſagreeable and peculiar flavour from various vegetables. We are informed that all plants of the garlic kind, many of the umbelliferous, the horſe mint, cabbages, turnips, autumnal leaves, give it their peculiar flavour. According to Anderſon, it is not uncommon to find the milk of farrow cows ſenſibly ſaline to the taſte, particularly that which is firſt drawn; and that, at laſt, it becomes perfectly ſweet, the ſaltneſs gradually decreaſing from the beginning, and not to be obſerved when about one half was drawn off; and perhaps the ſame circumſtance may be found to take place in milk flavoured by vegetables. Cows that feed on the leaves of maize, give an extremely mild and ſaccharine milk; and fed on the potatoe plant, it is inſipid. Likewiſe, the Alderney breed, and the Alpine cows afford a very rich milk both in colour and conſiſtence, whilſt the northern cows give an aqueous and bluiſh milk: the milk of Sardinia is ſo rich as to afford one half of cream, whilſt that of Catalonia yields very little. In ſummer milk is more or leſs yellow, and in winter white. With reſpect to it's colour, we are informed by Teſſier, of the French National Inſtitute, that he has obſerved milk newly drawn from the cow, and of a beautiful white colour, to become blue in the courſe of two or three days; this was attributed to ſome plants of the nature of woad or indigo, on which cows will ſometimes feed; and Dr. Garden found, that after cows had eaten the ſame plant in an indigo field, the cream of their milk was of a moſt beautiful blue colour. Boiling, although it in ſome meaſure diſſipates the diſagreeable taſte of plants, had no effect on the colour. Cows that feed on the madder plant, give a milk that appears ſtreaked with blood; and after eating the fruit of the cactus opuntia, milk of a reddiſh colour. Gugenmus gave the madder plant formed into hay to his cows, which ate it readily; their milk was ſomewhat reddiſh, and the butter and cheeſe acquired by theſe means, in winter, an agreeable colour.

The milk of the cow, in it's ordinary ſtate, boils at a degree above that of boiling water.

Effects of reagents upon it.

Fixed air has no effect upon it, neither has ſedative ſalt.

The vitriolic acid coagulates it into thick lumps, which are ſcarcely afterward diſſolved by potaſh; the other acids act in a ſimilar manner, ſuch as the nitrous, muriatic, phoſphoric, and the coagula are rediſſolved by an alkali.

Vinegar, whether concentrated or not, coagulates it, and the lumps are again diſſolved by alkalis, and become of a roſe colour.

The oxalic acid, according to Stipriaan, only coagulates it when ſtrewed in the form of a powder.

The carbonat of potaſh converts it into a jelly, and if heat be employed, it changes it's colour (or rather the colour of the whey) to a yellow red, and at laſt a brown. Cauſtic alkali diſſolves it with a yellowiſh colour.

Ammonia thins it, and on boiling heightens it's colour.

Lime water thickens it a little.

Neutral ſalts make it thinner, previous to their thickening it.

According to Stipriaan, highly rectified ſpirit of wine does not coagulate it.

Infuſion of the dried ſtomach of a calf coagulated it.

The electric fluid thickened it ſomewhat.

On ſubjecting it to the vinous fermentation, Stipriaan obtained from it by diſtillation a hot ſpirit.

When the milk is coagulated by artificial means, a mild agreeable ſeroſity is produced of a lemon colour, which is the whey or ſerum.

It's ſpecific gravity to that of pure water was in ſummer as 1028 to 1000.

Diſtillation. We are informed by Parmentier, that on diſtilling the milk of cows fed on different food, he obtained eight ounces of a clear and colourleſs fluid from eight pounds of each milk, but the odour and ſavour were ſimilar to the food of the animal, that lived for nearly one month in a temperature of 16 to 18° of Reaumur. Theſe fluids began to prove turbid and viſcous, and their odour was a little fetid; that obtained from the milk of the cow fed on cabbage underwent a more ſudden and ſenſible alteration than the others, and was ſometimes the firſt to become putrid. Theſe liquors, arrived at the viſcous and opake ſtate, became perfectly tranſparent again at a heat of 28°, whilſt ſome ſlight white filaments were formed, (and this is the caſe with liquors obtained by the ſame means from fleſh, white of egg, and other animal ſubſtances; all the liquors, which are at firſt very limpid, become turbid at the end of a certain time, loſe their odour, and acquire another which is in general very diſagreeable). On filtration, they become perfectly clear, without ſavour or odour, and on evaporation to dryneſs, little or nothing was left to collect. The reſiduum was thick, greaſy to the touch, of a yellowiſh white, mild, and even ſweet ſavour, and to it Hoffmann gave the name of *Franchipan.* By diluting this in boiling water, a milky liquor is obtained, known in France by the name of Hoffmann's whey. On diſtillation, an aqueous fluid, a very fluid yellow oil, an acid, volatile alkali, a thick black empyreumatic oil, and an inflammable gas are obtained. The carbonated matter, in the retort, is difficult to incinerate. The aſhes change the blue of violets green; when ſulphuric acid is poured on them, vapours of muriatic acid ariſe.

Franchipan.

It appears that, on changing the food, although for the better, the quantity of milk becomes very evidently diminiſhed, and it's increaſe is only perceptible after having been accuſtomed to the new regimen for ſeveral days. The aroma appears to form a conſtituent part of the milk. To this, it may be added, that the odour of the plants, diſtinguiſhed in the volatile parts of the milk, are not perceived in the fixed parts.

Change of food leſſens the quantity of milk.

Milk taken from the cow immediately after calving is called *beaſtings*, (coloſtrum primum;) it is of a yellowiſh colour; ſometimes mixed with ſtreaks of blood; it is thick and clammy; it's taſte is like other milk, but ſomewhat mucous.

Beaſtings.

It's ſpecific gravity to that of water is 1072 to 1000.

On the fire it ſoon coagulates and becomes of a whiter colour.

Milk of the ſecond drawing is not ſo yellow, thick, or heavy; it's ſpecific gravity was found by Stipriaan to be to water as 1052 to 1000. This is more difficult to coagulate, and ſtirring prevents it's coagulation.

Properties of it.

Beaſtings is coagulated by all the acids; the vitriolic makes it whiter and very thick; the muriatic and nitrous likewiſe thicken it, eſpecially the former. Vinegar only coagulates it in it's concentrated ſtate.

Alkalis thicken it, and give it different colours.

The neutral ſalts render it more thin.

It is coagulated by alcohol.

Rennet changes the firſt drawn milk into a jelly, and coagulates the ſecond.

Sixteen hundred parts of the firſt afforded 187 of cream, 48 of butter, and 300 of cheeſe; and the ſame quantity of the ſecond gave 64 of cream, and 202 of cheeſe.

Expoſed to the air in ſummer, they both become highly putrid in ſix or eight days, with the odour of putrid fleſh.

More animalized than ordinary milk.

This milk, eſpecially the firſt, is more animalized than the ordinary milk, and it's liquid part, or whey, agrees very much with the ſerum of the blood; it, however, contains very little of this part, on the contrary, a great deal of cream and butter. Independent of the caſeous part, it is very heavy, ſcarcely ever becomes ſour, but undergoes the putrid fermentation proportionably quicker. Stipriaan looks upon beaſtings to be milk united with a quantity of ſerum of the blood.

Cream.

Cream of the cow. This, on ſtanding, becomes thicker and of a deep yellow colour; it loſes it's pleaſant ſmell for one that is diſagreeable; and, according to Parmentier, it became covered over with a green efferveſcence in about the ſpace of three weeks, whilſt the under part had a caſeous ſavour. It afforded, on diſtillation, the ſame products as thoſe extracted from fat bodies; at firſt a yellowiſh oil, of a ſtrong and penetrating odour, with ſome drops of a liquor ſlightly acid; afterward volatile alkali; then a charcoal of difficult incineration, but no fixed alkalis were found in it.

Anderſon's obſervations.

We are informed by Dr. Anderſon, that the quantity of cream, collected from the milk of the cow, is different according to the time of it's being drawn, and that a ſmall quantity of milk which comes the laſt contains about ſixteen parts more cream than the ſame quantity drawn the firſt, at the ſame milking; that the cream is much richer, it's colour of a deep orange, whilſt that of the other is white. He informs us, that the cream in the firſt caſe was a thin tough film, thinner and perhaps whiter than common writing paper, whilſt in the laſt drawn cup it was of a thick butyraceous conſiſtence, and of a glowing richneſs of colour, as he expreſſes it, which no other cream is found to poſſeſs. From theſe experiments, "it appears," ſays Dr. Anderſon, "that a perſon, who by bad milking of his cow "loſes but half a pint of his milk, loſes in fact about "as much cream as would be afforded by ſix or eight "pints at the beginning; and loſes, beſides, that part "of the cream which alone can give richneſs and high "flavour to his butter."

If milk be put into a diſh and allowed to ſtand till the cream ariſes to the ſurface, that portion of cream which ariſes firſt is richer in quality and greater in quantity than that which riſes in a ſecond equal ſpace of time; and that which riſes in the ſecond interval of time is greater in quantity and richer in quality than in the third equal ſpace of time, and ſo on. The cream that riſes decreaſing in quantity and declining in quality as long as any riſes to the ſurface.

Dr. Anderſon found, that thick milk always throws up a ſmaller proportion of cream it contains to the ſurface than thinner milk, but the cream is of much richer quality. If water be added to this rich milk, it is found to afford a much greater quantity of cream than it otherwiſe would have done, but it's quality is debaſed. Neither does milk which has been previouſly agitated by carriage afford ſo rich a cream, nor in ſuch quantity as when it is left to repoſe after having been drawn. In this caſe, it is ſuppoſed, that the loſs of cream will be nearly in proportion to the time elapſed, and the agitation it has ſuffered ſince the time of being drawn.

With reſpect to the ſeparation of cream from the milk, it appears, that it takes place with the greateſt regularity in a temperature of from 53° to 55° of Fahrenheit, which temperature it is neceſſary thoſe who are engaged in the dairy ſhould be acquainted with; for when the heat exceeds 63° this operation becomes very difficult, for the milk is apt to become ſour and to coagulate ſuddenly without permitting the ſeparation of the cream; if, on the other hand, the milk is kept in too cool a temperature, as under 40°, the cream ſeparates from it with great difficulty and very ſlowly, and acquires a bitter and diſagreeable taſte.

Milk, in the autumn, is much richer and more coagulable, and gives more cream than in the ſpring. It likewiſe gives it's cream ſooner in ſummer than in winter. This ariſes from the heat which, by giving more fluidity to it's particles, permits them to act according to their ſpecific gravity. If, however, this heat be too ſtrong or ſudden, an acid is produced which coagulates the caſeous part before the cream has had time to ſeparate. This is the caſe in ſtormy weather.

Fourcroy ſuſpects, that the electric fluid is the principal cauſe of this effect; for a good conductor paſſing in the middle of a dairy prevents, or at leaſt very much retards this coagulation during ſtormy weather. Cow's milk requires twice the time in winter to give it's cream to what it does in ſummer. According to Fourcroy, four or five days are ſufficient in ſummer, and eight or ten in winter, before all the particles of cream can ariſe; it muſt likewiſe be kept at eight or ten of Reaumur; it will not cream at all at zero, and it freezes a few degrees below it.

Butter.

The butter of the milk of the cow is in general of a yellow colour; but ſometimes it is as white as fat or lard, and is of an inferior quality. The colour, however, depends on the ſerum, the phyſical ſtate of the animal, and other circumſtances. If the cream be got from milk, expoſed to too low a temperature, the butter when extracted will be pale, very ſmall in quantity, of little taſte, very hard and brittle, and of no value. Butter, likewiſe, extracted from new cream, has a more agreeable ſavour than when extracted from old; for to make butter of the beſt quality, it will not only be neceſſary to ſeparate the firſt drawn milk from the reſt, but likewiſe to take only the firſt cream that is ſeparated from the beſt milk, as it is only the firſt riſing cream, that is of the beſt quality. Thus the richneſs of the highland butter is attributed, by Dr. Anderſon, to the practice of giving the firſt drawn milk to the calves, and keeping the reſt for the dairy; and the quality and richneſs of the butter will be improved in proportion to the ſmallneſs of the quantity of the laſt drawn milk. Another circumſtance in the ſeparation of butter from cream is, that it does not take place till after the laſt has attained a certain degree of acidity; if, therefore, it be agitated before that acidity has begun, no butter can be obtained; and, according to Anderſon, the agitation muſt be continued until that ſourneſs be produced, after which the butter begins to form; hence, the cream ought to remain in the veſſel appropriated for keeping it, until it has acquired that proper degree of acidity by which butter is eaſily extracted, by a very moderate degree of agitation; and by this proceſs only can very fine butter be obtained. In ſummer, while the temperature is warm, if the agitation be continued till the acidity is produced, the proceſs will be long and tedious, and the butter is generally of a ſoft conſiſtence, and gluey to the touch; whilſt, if the ſame be attempted during the cold in winter, butter can ſcarcely in any way be obtained except by the application of a great heat, which ſometimes aſſiſts in producing a very inferior ſort, white, hard, and brittle, reſembling that before mentioned; when the milk has been expoſed to too low a temperature, it has very little taſte, and is unfit for culinary purpoſes. Cream, therefore, which has been kept three or four days in ſummer, is in excellent condition for producing butter; and Anderſon is of opinion, that from three to ſeven days will be found in general to be the moſt proper time for keeping cream before it is churned.

Robinſon's obſervations.

According to Mr. George Robinſon, butter from cream is much richer than that from milk, but is leſs in quantity, and does not keep ſo long ſweet; a good cow will produce from ſeven to ten pounds of butter every week.

With reſpect to the yellow colour of butter, it is pretended, by ſome people, that it is owing to the aliments; but it is well known that cows, when feeding on the ſame food and in the ſame paſtures, ſometimes give yellow, and at other times white butter; hence it appears, that it is in ſome meaſure to be attributed to the conſtitution of the animal. At the ſame time, it cannot be denied, but that the aliments may have ſome ſhare in it's coloration. The contact of the air has likewiſe an effect in colouring butter, for ſometimes that which is quite white acquires a yellow colour a certain time after it's preparation; and butter, on being cut, will ſometimes be found to be much leſs coloured internally than externally.

Fourcroy. According to Fourcroy, it is neceſſary to wait ſome time after the cream is formed, before the butter is extracted from it. It appears to him, that the cream abſorbs a portion of oxygen from the air, which thickens it, and diminiſhes the attraction of the butyraceous particles for thoſe with which it was united in the liquid cream; ſuch are principally the caſeous particles and thoſe of the gelatinous mucilage, a proportion of which is ſeparated from the cream by the mechanical operation of churning. It appears, that the air very much facilitates the ſeparation of the cream from the milk, for when milk is placed in vacuo it does not give up it's cream ſo readily, nor is the cream ſo thick and abundant as when expoſed to the air at the ſame temperature. It appears that cream, taken from milk of twenty-four hours ſtanding, requires at leaſt four times longer to give butter than that of eight days, and four times more motion; for it is neceſſary that it take in a few hours from the atmoſphere in the one caſe, what it had in the other imbibed in ſeven days, for which purpoſe the points of contact muſt be multiplied and renewed in proportion, which is brought about by churning. Theſe facts appear to Fourcroy to prove, that the butter is not wholly formed in milk; that it is there in a ſtate of oil, which muſt abſorb a certain quantity of oxygen before it can become concrete.

Parmentier. Parmentier is not of the ſame opinion. "Whatever doubts," ſays he, "may be formed of the preexiſtence of butter in cream, it muſt be allowed that cream has the general properties of oily matters. It is ſpecifically lighter than milk; is unctuous to the touch; it ſpots cloth like fat bodies; it grows rancid, and at length contracts a ſtrong taſte, which gives reaſon to ſuppoſe that butter is contained in cream, but under a ſemi-combination, which agitation alone can deſtroy." He has endeavoured to ſupport this opinion by experiment. He endeavoured to deprive cream of it's ſerous part, which conſtitutes it's fluidity, without altering it's properties; for which purpoſe he procured a certain quantity upon ſeveral leaves of grey paper, which, after being impregnated with the ſerous part, left the cream as ſolid as butter. It was then collected and diluted with a certain quantity of diſtilled water, ſufficient to reſtore it to it's former fluidity; and on agitating the fluid, the butter ſeparated as uſual; the ſeroſity was only extremely inſipid; which, according to Parmentier, was a proof that the ſaline matter diſſolved in the ſerum does not ſerve as an intermediate body to unite the butter with the cream. Some drops of vinegar added to freſh cream, in order to attack the caſeous part, had no effect in promoting the extraction of the butter, but retarded it, and the laſt retained a little of the caſeous part into the bargain. This experiment likewiſe proves, according to this chemiſt, that the promptitude with which the butter ſeparates from ſour cream depends leſs on an acid developed in this fluid, than on the ſpecies of fermentation which has produced this acid.

Beſt ſorts of Engliſh butter.

They who are deſirous of knowing the method of making good butter ſhould attend to the methods which are employed in the beſt dairies; ſuch is the *Weſt country* method, as Dr. Anderſon has called it. They firſt depoſit their milk in earthen pans, and let them remain twelve hours in ſummer and twenty-four in winter; they are then removed to ſtoves, heated for that purpoſe with hot embers; here they remain till bubbles ariſe and the cream changes it's colour, this is called *ſcalded* cream. It is then removed with care to the dairy, where it remains twelve hours longer, when it is ſkimmed, and the cream is churned. The Cambridgeſhire ſalt butter is made nearly in the ſame manner, and is in the higheſt eſteem. This, when deprived of it's ſalt by waſhing, is ſold at a high price in London as freſh butter. Nearly the ſame method is purſued in Suffolk and Yorkſhire, and the butter is not much inferior to that of Cambridge, being often ſold in London for that butter. The food is often found to affect the butter, as wild garlick, charlock, or May weed, turnips and rape. A great part of the Epping butter, according to Dr. Anderſon, is made from the cows that feed, during the ſummer months, in the foreſt, where the leaves and ſhrubby plants greatly contribute to it's flavour. The mountains of Wales, the highlands of Scotland, and the moors, commons and heaths of England, produce excellent butter where it is properly managed; and though not equal in quantity to that produced from rich meadow land, yet is ſuperior in flavour and quality.

Preſervation of butter.

To this ſhort digreſſion on the making of butter in the dairy, may be added this method of preſerving it: To preſerve butter more effectually than ſalt from any taint of rancidity, the following preſcription has been uſed: One part of ſugar, one of nitre, and two parts of the beſt Spaniſh ſalt, are to be finely pulverized together, and kept for uſe; one ounce of this is to be mixed thoroughly with ſixteen ounces of the butter, as ſoon as it is freed from the buttermilk; it is then to be put into a cloſe and perfectly clean dry veſſel, from which the air is to be carefully excluded, and it will remain good for many years.

Rancidity.

Butter muſt be divided into ſmall portions and well waſhed, until the water ceaſes to be milky, otherwiſe ſome portions of the cream will remain, by which it ſoon loſes it's delicate flavour for a ſtrong diſagreeable ſharp taſte, vulgarly called *rancidity*. Butter appears to be more ſuſceptible of this ſpontaneous change than other oily matters. This may be retarded by keeping it in a cool place, or mixing ſalt with it. Parmentier waſhed, more or leſs perfectly, equal quantities of butter of his own making from excellent cream, and when placed in the ſame temperature they became ſooner or later rancid, according as they were more or leſs well waſhed. To prove, in a ſtill more evident manner, the preſence of cream or milk in butter, and it's action on this oily body, two ounces of freſh butter were melted by a gentle heat in a ſmall pot, and an equal quantity of rancid butter in another veſſel; after cooling, a ſmall portion reſembling cream was found at the bottom of the veſſel; that of the firſt had a mild ſavour, whilſt that of the ſecond was very ſharp. This effect became infinitely more ſenſible on increaſing the fluidity of the butter, by adding equal parts of oil of ſweet almonds. Suppoſing theſe experiments not ſufficient to prove the influence of the caſeous matter on the rancidity of butter, it is ſufficient to pay attention to the daily practice of dairymaids, who, on melting their butter, find the caſeous matter precipitated to the bottom and torrified; likewiſe, by kneading rancid butter with water, it will ſoften it's ſtrong taſte. With reſpect to rancidity proceeding from an acid, as ſome chemiſts have imagined, it is proved by experiment, that neither rancid butter, nor old cheeſe, either coagulates milk or reddens the blues of vegetables.

Pure butter, expoſed to a gentle heat, melted and well waſhed, does not become rancid ſo ſoon as other butter, but it is not ſo agreeable to the taſte; and it appears probable to Fourcroy, that it is on this account a certain quantity of cheeſe is always left in it, which renders it opake, and which may be ſeparated by gentle fuſion; the butter, likewiſe, is more marrowy after fuſion. Fourcroy put ſome freſh butter of the market into a tube of one inch diameter, ſtopped it at one end, and plunged it into hot water; at the temperature of 28° it ſeparated into three parts; the cheeſe was at the top, apparently drawn there by ſome air blebs which appeared to adhere to it more than to the other matters; the pure butter was in the middle, and water in the inferior part.

Butter, melted by this gentle heat, has not the ſame properties as before; it's colour, ſavour, and texture are changed; it is become ſemitranſparent, and granulated; it's ſavour is inſipid and ſimilar to that of fat: theſe changes which butter undergoes in melting, are cauſed by the ſeparation of the caſeous part and the mucilage. *Vide* oils, article butter.

Butter-milk.

Buttermilk. We are informed by Parmentier, that this fluid reſembles perfectly ſkimmed milk, in all it's phyſical, chemical, and economical properties. When it is acid, as happens in the ſummer months, or when it is taken from old creams, it has a ſavour manifeſtly ſharp, and is leſs white than common milk; it is then clarified with extreme quickneſs, the developed acid coagulating one part of the caſeous matter, and the ſolution the other. Buttermilk is not ſo ſharp as the acid cream from which it is taken, owing to the percuſſion during churning having either deſtroyed the acid or forced it to combine with the caſeous matter; buttermilk, therefore, differs from milk only by being completely deprived of it's butyraceous matter.

Skimmed milk.

Skimmed milk. Milk, when deprived of it's cream, has neither that dead white colour which it has in winter, and yellow colour in ſummer, nor that unctuous conſiſtence and ſweet ſavour which it has when freſh drawn; and as it's denſity is decreaſed it is boiled by an inferior heat. It is likewiſe capable of diſſolving a greater portion of ſugar, and other ſaline bodies. It is owing to the abſence of the cream in this milk that it is preferred for whey, the clarification being more complete, and it does not ſpoil ſo ſoon. If ſkimmed milk be left in the open air, or even in a bottle, it loſes it's ſweet ſavour, contracts a ſharpneſs, and changes into a ſerous liquor; in the midſt of which floats a coagulum which is eaſily ſeparated by decantation, eſpecially if the veſſel be expoſed to a gentle heat, and is the caſeous part.

If this milk, which has juſt begun to turn ſour, be put into a veſſel and placed in ſome heated water for one night, this caſeous matter will be ſeparated into a thick creamlike ſubſtance and occupy the upper part, which is not much leſs in quantity than one half of the milk; when this is well done, it appears to be as rich and fat as real cream, and is only to be diſtinguiſhed from it by it's ſourneſs; it is eaten with ſugar, and is eſteemed a great delicacy; it however requires practice to make it nicely, and give it a proper creamy conſiſtence; the degree of heat and other minute circumſtances greatly affecting the operation.

Skimmed milk being expoſed to heat on the baln. marin. pellicles ariſe as before-mentioned, article *milk.* In proportion as they are formed, the milk becomes thick, hence, water muſt be added to preſerve it's fluidity; when it ceaſes to give theſe pellicles it is tranſparent and fluid, and no longer to be curdled by acids; in ſhort, it is whey, or the ſerum of the milk. Being left ſix days in a veſſel, theſe pellicles gave an inſupportable odour. On the fire, they bliſter and expoſe an odour of burnt horn, and afford on diſtillation the ſame products, viz. phlegm, light oil, ammonia, and an empyreumatic oil; a charcoal remains of difficult incineration. One of the moſt remarkable properties of theſe pellicles is, to be diſſolved by cauſtic ſoda. The ſolution is of a deep red. This colour Parmentier thinks is due to the carbon, which is firſt ſeparated and then diſſolved by the ſoda.

Caſeous matter.

The caſeous matter, being the ſame as the pellicles juſt mentioned, poſſeſſes their properties; when freſh and moiſt, it is in part ſoluble in the alkalis, but when exſiccated they act very little on it. The manner in which fixed alkalis act on freſh curd merits a particular examination. When flakes of cheeſe are put into liquid and cauſtic potaſh or ſoda, they become tranſparent, and are diſſolved, whilſt a great quantity of ammonia is diſengaged, as obſerved both by Fourcroy and Parmentier; the ſame takes place with the gluten of wheat, and animal ſubſtances, as fleſh. This ammonia appears to Fourcroy to be formed at the moment of the action of the alkali, for freſh cheeſe has no character that indicates it's preſence; it neither changes blue vegetable colours green, nor gives ammonia at a mild temperature. It appears, therefore, that during the time the fixed alkalis tend to unite with a certain portion of cheeſe; it's principles immediately change in their attractions; a certain quantity of it's hydrogen and azot combines apart to form ammonia; the water contributes much, for the production of ammonia does not take place in dried cheeſe.

That portion of cheeſe which the alkali holds in ſolution gives the liquor a browniſh yellow colour, which becomes brown on the application of a little ſtrong heat; in the laſt caſe a ſmall quantity of carbon is depoſited. This matter may be ſeparated from the ſoda and potaſh by an acid; but then it no longer poſſeſſes the ordinary properties of cheeſe. It has a black colour, melts in the fire like a thick oil, becomes dry no more, but remains greaſy. It appears that the azot and hydrogen are firſt diſengaged to form the ammonia, whilſt the hydrogen and oxygen becoming more abundant in the caſeous matter, give it it's oily characters, ſo that it's ſolution by the alkali forms a ſort of ſoap.

According to Parmentier, if this combination of the caſcous matter with ſoda be decompoſed by an acid, an hepatic odour is diſengaged. He found that the vitriolic acid has very little action on the caſeous matter. The fuming nitrous acid diſſolves it at a boiling heat, but diſtilled vinegar he found to be the acid which (contrary to Scheele) the moſt completely diſſolved it.

Scheele has ſhown that the acids in coagulating cheeſe diſſolved a part of it in proportion to the quantity of acid employed. According to Fourcroy, the caſeous part has a ſtronger attraction for ſome acids than for others, and in general for the vegetable acids, as vinegar, lactic acid, and amongſt the mineral acids for the diluted ſulphuric. It has likewiſe a ſtrong attraction for the ſweet ſerum of the milk, ſince this liquid by whatever means it has been clarified, always depoſits ſome of it on paſſing to the acetous ſtate.

Whey. The ſavour of this fluid, when freſh, is ſweetiſh and ſomewhat ſaline, and when filtrated, poſſeſſes the greateſt limpidity. Mixed with the fixed or volatile alkalis a white depoſit is formed, which is a portion of the caſeous matter held in ſolution by an acid. On the addition of an acid, it is expelled.

Whey is uſed in the bleaching of linen. It is left eight or fifteen days in large veſſels of this fluid, and taken out perfectly bleached. In this caſe the acid of the whey is decompoſed, and the oxygen acts on the colouring matter.

Serum, evaporated and placed in a freſh place, affords white cryſtals, which are the ſugar of milk. Parmentier found no fixed alkali in the mother water, only the muriat of lime was preſent. Hence he concludes with Rouelle, that fixed alkali is not eſſential to milk, and that when found in it, it is, like all the neutral ſalts, carried there by the nouriſhment or drink of animals.

The beſt cheeſes in England, ſuch as the Stilton, the Cheſhire, and the Glouceſter, are made from the milk of the cow, and their difference appears to depend more on the manner of making them, than on any peculiar properties of the milks. According to Parkinſon, the Stilton is made of the curds from ſour and ſweet milk mixed together, and the whey preſſed lightly out; and the richneſs depends in ſome meaſure on the quantity of cream. It is afterward turned often, and not dried too quickly. Cheſhire cheeſe is made of new milk, and it's rich flavour and mellowneſs are owing to an addition of ſweet beef ſuet, or any other which is poured into and mixed with the curd, with a ſufficient quantity of ſalt to keep it from rancidity. It is found that the hotter any kind of cheeſe is put together, the ſounder it will be; and the colder you put it together, the richer it is, and the ſooner it will decay. Another ſort made of this milk, and of great celebrity, is the Cottenham, or Eddiſh cheeſe; it is thin and ſoft. English cheeſes.

HUMAN MILK.

THIS milk is of a ſlight bluiſh colour, it's ſavour mild and ſaccharine, and of a ſweetiſh odour.

It's ſpecific gravity is to diſtilled water as 1029 to 1000.

Expoſed to the air in a freſh place, it's ſurface becomes covered over with a thick very white matter analogous to cream. From this cream Parmentier could procure no butter by agitating it for ſeveral hours; it was then left in a temperate place, when on the ſecond day a very clear colourleſs liquor was obſerved at the bottom of the veſſel, and on the ſurface was a thickiſh fluid, very white and of a mild and unctuous ſavour, but butter could not be Expoſure to the air.

Diſtillation. ſeparated from it. It was then put into a retort and diſtilled, which forced over ſome phlegm, a ſtrong empyreumatic oil, volatile alkali, an acid, and inflammable gas; the liquor, therefore, on which this analyſed matter ſwam may be looked upon as a butter milk; it's tranſparency was not changed either by acids or ſpirits of wine. By inſenſible evaporation it afforded a ſaline reſiduum, found to be ſugar of milk, mixed with ſome caſeous matter. Human ſkimmed milk placed in rather a warm temperature did not coagulate in five days, it became, however, turbid from the evaporation, and ſenſibly acid. On letting the evaporation continue, cryſtals of ſugar of milk were formed, and there remained at laſt a thick mother ley, which, evaporated to dryneſs, afforded muriat of ſoda. When heated for pellicles to appear, they aroſe ſucceſſively as in the milk of cows, and the reſt was ſerum.

Coagulation. All the methods of coagulation uſed in cows milk ſucceeded, except vinegar, and the mineral acids very much diluted with water.

It appears that the longer a milk is drawn from the time of lying in, the more caſeous matter it contains, and then it is coagulated by acids; but the coagulation is always viſcous, and never acquires that gelatinous conſiſtence obſerved in the caſeous matter of the cow. The cream of human milk ſoon after lying in is very ſmall in quantity, but it increaſes as it recedes from that time; this cream is always of a dead white colour, which in a ſhort time becomes of a thick conſiſtence, without acquiring, however, that unctuous appearance which characterizes the cream of the cow. The obſervations which Parmentier has made on this milk are highly deſerving of attention.

Curd.

Cream.

It's conſtituent parts difficult to aſcertain.

"Perhaps," ſays this chemiſt, "there is no ſpecies of milk the products of which vary ſo much as the human, hence the inſufficiency of every comparative analyſis with that of other females. At each inſtant of the day, this fluid changes it's ſtate, and the changes it undergoes are ſometimes ſo marked, as to aſtoniſh the moſt experienced obſervers. We were at firſt ſo much ſtruck with theſe differences during the ſame day, that we were apprehenſive the milk might have been diluted with water. To avoid this ſuſpicion, we analyſed only that which had been drawn in our preſence. But the conſequences being ſtill the ſame, we concluded, that it can never be in the power of the chemiſt to determine the quantities of each of the conſtituent parts of this fluid in a manner ſufficiently poſitive to obtain a term of compariſon, that will not be variable, ſince it is impoſſible to find two kinds of this milk perfectly ſimilar."

Cream compared with that of the cow.

The cream appears to be in a greater abundance in human milk than in that of the cow, and it differs from it very eſſentially in it's component parts. In that of the cow the butyraceous particles are as it were mixed with the caſeous part of the ſerum, and agitation alone is ſufficient to produce the butter; but in the human cream, the caſeous matter is not only ſimply mixed with the butter, but it is ſo combined as to appear impoſſible to ſeparate it. Beſides, the human butter is moſt probably leſs ſolid than that of the cow, becauſe the cream which contains it only acquires by percuſſion a thickiſh conſiſtence; perhaps it is likewiſe to the ſmall diſpoſition which the butter has to take a concrete form, that the impoſſibility of it's ſeparation is owing, and the property it has of remaining combined with the caſeous matter from the greater affinity of their particles. "In ſhort," ſays Parmentier, "to be convinced that the caſeous matter and butter exiſt in human cream, it is ſufficient to know that the cream very ſoon grows rancid, and that the products it gives by diſtillation in the open fire are preciſely the ſame

Butter.

as thoſe from the cream of a cow treated in the ſame manner." The property of the human milk, in not being always ſubject to coagulation by acids, appears to depend on the ſmall quantity of caſeous matter it contains, and it's extenſion in this fluid; and this explanation is confirmed by Scheele's experiments, which prove that cow's milk, diluted with ſix parts of water, loſes the property of coagulation. It alſo appears that the caſeous part adheres very ſlightly to the ſerum; ſince by repoſe alone, it is found in great part to ſeparate from it in the form of exceedingly tender molecules adhering to the ſides of the veſſel. Another character which diſtinguiſhes this milk from that of the cow, is the ſaccharine ſavour; yet the quantity of ſugar the human contains is ſcarcely ſenſibly greater. Perhaps the cauſe of the great developement of the ſaccharine matter in this milk ariſes from it's not being as it were maſked by that of a great quantity of caſeous matter.

Stipriaan's experiments.

From the experiments of Stipriaan, the human milk was not coagulated by any of the acids, whether heat was uſed or not; nor was it coagulated by any of the alkalis, mild or cauſtic: ſoda of potaſh, however, by the means of heat, gave it a yellow, brown, red, and at laſt a black colour, which colours were weakened by the vitriolic acid.

Lime water, when boiled with it, produced a deep yellow colour.

The earths, neutral ſalts, &c. occaſioned no change.

Infuſion of oak bark formed a coagulum of a yellow colour.

Alcohol had no effect upon it.

Vitriol of copper, and the ſolutions of this metal in muriatic acid and vinegar, produced a blue colour; a ſolution of ſilver in nitrous acid gave it a dirty roſe colour; and tin in the ſame acid a beautiful roſe red.

The rennet of the lamb and calf did not coagulate it.

Sour coagulated milk when added to it produced a coagulum.

The electric fluid had no effect upon it.

The coal after evaporation afforded particles of iron.

The caſeous part was coagulated by either letting it become ſour and boiling it, or uſing old ſour milk; this cheeſe was much finer, more tender, and ſofter than that of other milk; it, however, cannot be collected in a lump. Sixteen hundred parts of this milk afforded 137 of cream, 48 of butter, 43 of cheeſe, and 117 of ſugar; 300 parts of this laſt gave 85 of lactic acid.

Contents.

Acetous, vinous, and putrid fermentations.

Human milk becomes difficultly ſour, it requires very often a fortnight and longer; ſometimes when it has been kept a long time, it is inſipid, and remains for months without undergoing the acetous fermentation; from 300 parts of the ſugar, Stipriaan obtained 85 of the acid of ſugar of milk. He was unable to bring it to the vinous or putrid fermentations.

Clarke's ideas on coagulation.

It is, perhaps, owing to the great difficulty, if not impoſſibility of procuring this milk in a nearly ſimilar ſtate, which ſome authors have attributed to the irregularity of the human method of living, that the experiments of chemiſts differ ſo much reſpecting it's coagulation; as there is no other milk which is ſo readily affected by the difference of nouriſhment. It is now aſſerted by Dr. Clarke, that it contains little or no caſeous part. He attempted it's coagulation with all the different acids, alcohol, heat of various degrees, infuſions of infants ſtomachs in various proportions, and aſſiſted by different degrees of temperature, without the leaſt ſucceſs. He confirms in this reſpect the experiments of Ferris and Young, and ſtates againſt Dr. Rutty, that if he had previouſly ſkimmed the milk, from which, by the means of rennet, he thought he had produced a little curd, he would have been unſucceſsful. From his own experiments, which have been numerous and of great variety, he concludes that the matter often vomited up by ſucking infants, and which has been ſuppoſed to be coagulated milk, is not the caſeous part, but a ſoft viſcid matter, which he looks upon to be the cream. He was confirmed in this opinion, by obſerving that the human milk always threw up a copious yellow cream for ſome days after delivery, and having interrogated the nurſes at the Lying-in Hoſpital on this ſubject, they informed him that the matter vomited up was yellow only during the *beaſting period*, and that it afterward is white.

MILK OF THE ASS.

THIS milk is of a whitiſh colour, and according to Stipriaan, not ſo opake as the other kinds. It has a peculiar odour and ſomewhat ſweetiſh taſte, accompanied with a ſlight ſaltneſs.

It's ſpecific gravity is as 1023 to 1000.

All the acids except the weakeſt, as the fluor acid, coagulate it.

Properties. Alkalis produce a very ſlight coagulation and various colours.

Neutral ſalts render it ſomewhat thinner.

Cream of tartar only coagulates it when warm.

Alcohol, rennet, ſolutions of lead, zinc, tin, iron, and copper in acids, coagulate it, and likewiſe produce more or leſs deep colours.

The coal after diſtillation afforded particles of iron.

This milk difficultly coagulates ſpontaneouſly, and the coagulum is not very conſiſtent.

The *cream* is of a yellowiſh white colour, ſweet ſapid taſte, and at firſt thin, but afterward thickened in conſiſtence.

The whey is ſweetiſh and of a yellowiſh colour.

The ſaccharine matter poſſeſſes a ſlight ſaline ſavour. Sixteen hundred parts of this milk afford 47 of cream, 53 of cheeſe, and 72 of ſugar of milk; 600 parts of this ſugar gave 155 of acid.

Obſervations on it's coagulation.

It appears that although all acids and ſpirituous liquors coagulate this milk, it is in a different manner from that of the cow, for the caſeous matter always ſeparates in the form of extremely tenacious particles, which aſſemble at the bottom of the veſſel, whilſt the coagulum of the milk of the cow is in a maſs, and occupies the whole of the fluid from which it is with difficulty detached.

Cream. Butter.

This milk affords a *cream* that is never thick or abundant; it is with difficulty converted into butter, and this butter when extracted from it is always ſoft, of a white colour, and without any marked ſavour. If care be not taken to ſeparate this butter from the buttermilk as ſoon as it is formed, or if it be kept in a warmiſh place, it liquifies and mixes with the buttermilk, and cannot be ſeparated again without plunging the veſſel into cold water, and then uſing agitation.

According to the experiments of Parmentier, this buttermilk well deprived of it's new cream has a very mild agreeable ſavour, and the caſeous matter is ſeparated from it by acids, &c.

Serum.

The *ſerum*, on evaporation, afforded a very white ſugar, but not in the quantity expected from it's ſweet ſavour; a little calcareous muriat was likewiſe found in the ſerum.

From the obſervations of Parmentier, it appears that aſſes milk is one of thoſe which contains the leaſt caſeous matter; it adheres ſo little to the ſerum, that repoſe alone without any acidity is often ſufficient to ſeparate it; it then appears in the form of very fine particles. In this, it agrees with the human milk, which is ſuddenly converted into ſerum. In proportion as the caſeous matter manifeſts itſelf, the ſaccharine ſavour becomes more evident, which effect cannot be attributed to the evaporation of the fluid, but to the evolution of the ſugar.

The cream is never in abundance.

From the want of ſufficient conſiſtence in the butter, it cannot be had in a ſolid ſtate during ſummer, and in winter it reſembles a fluid oil. It's colour is of a dead white, whether in ſummer or winter, which gives riſe to ſuſpect that it contains a ſmall portion of caſeous matter, and the facility with which it grows rancid ſeems to confirm this opinion.

The ſalts contained in the ſerum, Parmentier found were not always the ſame; muriat of lime was the moſt general, but he has likewiſe obtained an admixture of muriat of ſoda. The firſt was of the cubic form, the other in a ſtate of deliqueſcence, but the quantity of theſe two ſalts are very inconſiderable.

MILK OF THE GOAT.

GOAT's milk is very white, of a peculiar ſmell, and of a ſweetiſh, ſomewhat fat ſavour, which is very different from thoſe already mentioned.

It's ſpecific gravity is greater than that of the others; it is as 1036 to 1000.

With reagents, the changes in this milk are much the ſame as the laſt.

Cream. To ſeparate the *cream*, the milk muſt not be placed in too cool a place; the cream is exceedingly thick, of a mild and agreeable ſavour, and when expoſed to the air keeps a long time without ſuffering the acetous fermentation. From it's being ſo very thick, it is eaſily converted into a ſort of cheeſe, which keeps well, and is very rich. By agitation, butter is eaſily obtained; it is of a white colour, firm and ſolid in conſiſtence, and in other reſpects reſembles other butters. Butter.

The *buttermilk* abounds in caſeous parts; ſometimes it contains more than the human and cow's milk. It is mild and agreeable to the taſte, and it's caſeous matter may be ſeparated by acids, ſpirit of wine, &c. Buttermilk.

The quantity of curd is, from what has been ſaid, very conſiderable, and is always in the form of a magma, ſo thick as to cauſe the ſeparation of the ſerum with great difficulty. From the experiment of Parmentier and Deyeux, it appears that the abundance of caſeous matter in this milk is it's principal character; in this reſpect, it is very different from human and aſs's milk; it is to this circumſtance that it's great denſity is to be attributed, and the prodigious quantity of pellicles it affords on being heated. Another remarkable circumſtance is the gelatinous ſtate of this caſeous matter on it's ſeparating from the ſerum, being very different from that of human or aſs's milk, which never acquires any conſiſtence, but appears in the form of extremely divided particles. Independent of theſe properties, this caſeous matter of the milk of the goat, conſidered as an aliment, unites ſeveral others of great magnitude. Cheeſes are made from it which are extremely rich, marrowy, and melting, and of a very agreeable taſte. Abounds in caſeous matter.

As the cream is very thick, but never ſo yellow as that of the cow, the butter which is ſeparated is always white; this, however, like that of the aſs, does not depend on the interpoſition or combination of a certain quantity of caſeous matter. It's conſiſtence and manner of being acted upon by heat prove, that it does not depend on any foreign body for this property; beſides, after having been kept a long time, if melted on the fire, it affords no depoſit, as is the caſe when butter contains caſeous matter amongſt it's particles. It is moſt probably to this ſtate of perfection, that this butter has the property of keeping freſh a much longer time than any other.

From Stipriaan's experiments, it appears that 1600 parts of this milk contain 127 of cream, 73 of butter, 146 of cheeſe, and 70 parts of the ſugar of milk; one fourth of which is the lactic acid.

With reſpect to this laſt part, the ſaccharine matter, Parmentier's experiments prove, that in this milk it is not in proportion to the caſeous matter; it contains even leſs than the human and aſs's milk; it is always very white when the ſerum is ſpontaneouſly evaporated; if, however, artificial heat be uſed, the liquor at the term of cryſtallization remains ſirupy, and it's conſiſtence increaſes until it reſembles a jelly. The cryſtals are alſo coloured, which is the reaſon why the ſugar of this milk, which is made for commerce, is of a reddiſh colour. Theſe inconveniencies are avoided by ſpontaneous evaporation.

Parmentier found this ſerum to contain a very ſmall quantity of marine ſalt. It is the only foreign ſalt the preſence of which is ſeen in the mother water remaining after the cryſtallization.

MILK OF THE SHEEP.

Reſembles that of the cow.

IN appearance, the milk of the ſheep is very ſimilar to that of the cow, and their phyſical qualities have a great reſemblance.

It's ſpecific gravity is to diſtilled water as 1035 to 1000.

It eaſily undergoes the acetous fermentation in ſummer.

Left to repoſe, it is ſoon covered over with a thick yellowiſh cream, pretty large in quantity, of a mild and agreeable ſavour. This affords a good deal of butter, which never becomes of a very ſolid conſiſtence. It's colour is of a pale yellow, and leaves an oily impreſſion in the mouth. It eaſily becomes rancid, particularly if not well waſhed. The caſeous matter, whether obtained by ſpontaneous or artificial means, always, according to Parmentier, preſerves it's fat and viſcous ſtate, which prevents it's being eaſily collected; it's ſavour is mild and agreeable. The ſerum when evaporated afforded a very white ſugar. According to Stipriaan, 1600 parts of this milk afford 185 of cream, 93 of butter, 246 of cheeſe, and 67 of ſugar, which gave one fourth of the lactic acid, and nearly as much from the fluid which remained. All the acids, and even the acid of fluor, coagulate it; fixed air has no effect upon it.

Soda and potaſh gave it a dark colour; if cauſtic, a red. Ammonia appears to make it thinner, and gives it a yellowiſh colour.

The neutral ſalts have no effect upon it.

It is alſo coagulated by alum, liver of ſulphur when warm, and cream of tartar.

Although the difference between this milk and that of the cow is difficult to be aſcertained by inſpection, Parmentier found by analyſis, that it's characters are ſufficiently evident to prevent their being confounded together. This difference ſoon appears from the quantity of cream it furniſhes; afterward the butter extracted from it preſents to the chemiſt a ſtill more marked difference, both with reſpect to it's conſiſtence and taſte. With reſpect to the caſeous matter, the difference is ſtill more ſtriking, and affords a character which peculiarly belongs to it. It is remarkable for it's fatneſs and abundance.

From the richneſs of the butter, and the viſcoſity of the caſeous matter of the milk of the ſheep, it forms a part of certain kinds of cheeſe by mixing it with the milk of the goat; as in thoſe of Roquefort, which, without this admixture, would be too dry and leſs delicate, the milk of the goat giving it whiteneſs. This is one of the moſt famous cheeſes that France affords. As to the reſt, the ſuperiority which the milk of the ſheep is known to poſſeſs in giving to cheeſe it's richneſs, is recorded by this ancient proverb, *beurre de vache, caille de chevre, et fromage de brebis.* The muriat of ſoda found in this milk by the French chemiſts, has given riſe to a ſuſpicion of it's proceeding from the ſalt which is given to them.

Roquefort cheeſe.

From the celebrity of the Roquefort cheeſe above mentioned, it will not be departing from conſidering it in a chemical point of view to give ſome account of it's formation, and other properties.

Obſervations of Chaptal upon it.

We are informed by Chaptal, that the goats and the ſheep, of the milk of which this cheeſe is formed, feed upon the Larzac, a large plain of ten leagues in diameter, very fertile and rich: he affirms that it's quality ſeems to depend more particularly on the firſt operations in making. It often happens that cheeſe brought from different farms to Roquefort are of a very different nature, although from herds fed in the ſame manner. It is alſo frequently obſerved that cheeſe from the ſame farm, made by the ſame perſons, and with equal care, are of different qualities. Chaptal is of opinion that theſe varieties of quality originate from the firſt operations it undergoes in it's manufactory. He agrees in opinion with Huzard, in attributing the cauſes of the bad quality of cheeſe to the rennet. He thinks that it's ever variable nature; the ſojourning of the milk in the ſtomach of the calf; the variable quality of the curd; the more or leſs perfect mixture of the gaſtric juice with the food; the gaſtric juice itſelf; and even the age, conſtitution, and temperament of the animal; all of them have more or leſs influence upon it. To obviate theſe faults, the rennet ſhould be conſtant and invariable in it's nature and virtue, this muſt be looked for amongſt the acids. The manipulation has alſo great effect upon it. All the whey ſhould be entirely preſſed out, otherwiſe it becomes ſour in a few days and ſpoils the cheeſe. The cheeſe when made ſhould be dried in a freſh and dry air, and the month of May is the beſt ſeaſon for this purpoſe. Delmas has found ſuch cheeſe very ſuperior to others; the fermentation having been thus prevented, and perfect dryneſs obtained. They are preſerved in cellars of proper coldneſs, and with conſtant air.

The character of this cheeſe is mildneſs, whiteneſs, firmneſs, an agreeable taſte, and colour marbled with blue. It, however, ſoon changes it's quality from change of temperature and tranſportation; and ſo nice is it's point of excellence, that it is agreed upon by connoiſſeurs, that it is only at Roquefort an exact idea can be formed of it. The firſt degrees of fermentation when in curd make it inſenſibly loſe the inſipid taſte it has in that ſtate, and at laſt it contracts a ſharp diſagreeable ſavour; it is therefore between the extremes that the fermentation muſt be ſtopped. It is alſo neceſſary to attend to the changes after having been ſalted and placed in the cellars. It is firſt covered with a white down, which afterward becomes blue and then red. Theſe colours ariſe from the attraction of oxygen, which by producing a different denſity, or otherwiſe changing the poſition of the particles, renders them proper to refract ſuch and ſuch rays, according to the refractive power of each. As the blue ray is the weakeſt, it is the firſt reflected when the oxygen gas is fixed in a body, producing the putrid fermentation. The red which ſucceeds the blue in this cheeſe is likewiſe a natural conſequence of the ſame principle; and in effect, it is proved according to Chaptal, that the red ray is that which has the ſtrongeſt refrangibility, it is therefore that which is reflected when the concentration and combination of the oxygen gas is the ſtrongeſt; this is ſeen in the calcination of moſt of the metals, and in the blood; but the nature of the principles with which the oxygen gas combines, and it's greater or leſs affinity with the different particles, modify the combinations and vary the reſults. It is from this red colour that they are able to judge of the perfection of the cheeſe.

MILK OF THE MARE.

It's properties.

This milk, like the reſt, is white and opake; it's ſmell is peculiar to the animal, which it retains in all it's parts, and it has a ſweet and as it were an aqueous ſavour.

It's ſpecific gravity to diſtilled water is as 1045 to 1000.

The vitriolic, muriatic, and nitrous acids, coagulate it into thick lumps.

The phoſphoric acid deprives it both of colour and opacity, ſo that it appears like water.

Acid of fluor has no effect upon it in the cold, but when warm ſlightly coagulates it; a ſimilar effect is produced by the acid of ſugar.

The alkalis render it more thin, and change it's colour.

Lime water has no effect in the cold, but precipitates the caſeous part when warm.

Neutral ſalts render it thinner and clearer.

Highly rectified ſpirit of wine renders it equally curdy.

According to Stipriaan, an infuſion of rennet has no effect upon it.

This milk is ſomewhat remarkable for it's fluidity; it, however, is leſs ſo than the human, and that of the aſs, but it is more inſipid as to it's ſavour. It's phyſical properties have great reſemblance to other milks. Parmentier, however, obſerved that it eaſily boils, and is not difficult to coagulate. It's diſtilled water is nearly inodorous, and it gives a frangipane leſs unctuous and abundant than that of the cow. This milk ſcarcely feels the heat of the baln. mar. before it is covered with pellicles leſs than thoſe of the ſheep; and thoſe which appear the firſt are the moſt unctuous, which is to be aſcribed to the ſmall quantity of cream it contains.

The ſerum, when the pellicles are taken away, is always very clear and colourleſs. With reſpect to the cream, it is pretty clear and of a yellowiſh colour; it ariſes very ſoon after the milk is drawn from the animal. It affords no butter though agitated a long time; it increaſes, however, in conſiſtence, but affords no buttermilk, at leaſt Parmentier was not able to procure any. The ſkimmed milk has the properties of that of the cow and goat; it is, however, obſerved by the above chemiſt, that diſtilled vinegar and cream of tartar operated more difficultly the ſeparation of the caſeous matter, and when it appears ſome time after the mixture, it is in a form analogous to that of human milk treated in the ſame way. The ſerum by ſpontaneous evaporation was covered with a white cryſtallized ſalt in ſmall needles, ſometimes grouped, and ſometimes iſolated, and it likewiſe afforded a ſaline concretion; the firſt was found to be ſulphat of lime; the other, ſugar of milk; and after two other cryſtallizations, the liquor remaining refuſed to cryſtallize; it contained muriat of lime. Sixteen hundred parts of this milk, according to Stipriaan, afforded 13 only of cream, 26 of cheeſe, and 140 of ſugar of milk; 100 parts of this laſt gave 30 of the lactic acid.

The experiments of Parmentier and Deyeux on this milk, were made upon ſome which had been taken from the animals two months after foaling; they found, that on ſimple inſpection, it was eaſy to judge of it's ſerous ſtate, and they ſoon had a proof of it by the ſmall quantity of caſeous matter it contained. They found, that diſtilled vinegar would not coagulate it, as in the human; but it's caſeous matter was always made to appear of an extreme tenacity, when acids ſomewhat concentrated were employed.

The greateſt difficulty they found, was the ſeparation of the butter from the cream; and as Venel has obſerved, from the ſmall quantity of caſeous matter this milk contains, the nutritive property attributed to it muſt depend leſs on the abundance of the principles which enter into it's compoſition, than on the real manner in which they exiſt in it. With reſpect to the ſerum, theſe two chemiſts found, that the ſugar obtained by the firſt cryſtallization was covered and mixed with a ſaline matter, which they took to be ſulphat of lime; and this is the only milk which afforded them a ſalt of this kind.

Contains ſulphat of lime.

Since this milk appears to have been the firſt from which an ardent ſpirit was obtained, it may be thought neceſſary to give ſome account of it.

An ardent ſpirit firſt obtained from it.

It has been obſerved by travellers, that the different hordes of Tartars have for many ages been accuſtomed not only to prepare an agreeable aceſcent liquor from the milk of the mare, to which they give the name of kumiſs, but that they are able to extract by diſtillation a very ſtrong ſpirit from it. The method, however, in which this was done remained unknown; and we are informed by Grieve, that when he was in Ruſſia, it was with great difficulty he obtained the method of making it. He has given the following account of the method uſually practiſed in the preparation of kumiſs by the Beſchkir Tartars. Take any quantity of freſh mare's milk, add to it one ſixth part of water, and pour the mixture into a wooden veſſel. Uſe then as a ferment one-eighth of the soureſt cow's milk, but a ſmall portion of old kumiſs is beſt; cover the veſſel with a thick cloth, and place it in a moderate temperature; when on repoſing twenty-four hours, a thick ſubſtance will be collected on the ſurface, which is to be beaten with a ſtick until it is intimately mixed with the fluid part. After repoſing another twenty-four hours it is put into a narrow veſſel, and ſtirred until it is perfectly homogeneous; in this ſtate it is called kumiſs, and has an agreeable taſte, which is a compound of ſweet and ſour. It is ſtirred every time it is uſed. Grieve was told, that if this be put into cloſe veſſels, in a cool place, it will keep three months or more.

We are informed, likewiſe, by Eaton, who was many years reſident both in Turkey and Ruſſia, that the Arabians and Turks have a preparation ſimilar to the *kumiſs* of the Tartars; by the firſt it is called *leban*, by the Turks *yaourt*. It is made by putting ſome of the old ſort to new milk made hot over the fire, when in a few days, more or leſs, according to the temperature of the atmoſphere, it becomes coagulated into an uniform conſiſtence, and of a moſt pleaſant acidulous flavour; the cream is in great part ſeparated, leaving the curd light and ſemitranſparent; and the whey is much leſs ſubject to ſeparate than by our method of uſing rennet for the purpoſe of cheeſe making.

" Yaourt," ſays Eden, " has this ſingular quality, that left to ſtand it becomes daily more ſour, and at laſt dries, without entering the putrid fermentation. In this ſtate it is preſerved in bags, and in appearance reſembles preſſed curds after having been broken by the hands; and this dried yaourt, when mixed with water, becomes a fine cooling drink, or food." Freſh yaourt is an article of food amongſt the natives, and it appears that Europeans ſoon become fond of it. The ſame gentleman informs us, that no other acid will make the ſame kind of curd, for after the acetous fermentation is over, the whole becomes putrid; that in Ruſſia they put their milk in pots into an oven, and let it ſtand until it becomes ſour, and this they uſe as an article of food, or make it into cheeſe; but it has none of the qualities of yaourt, though when new reſembles it in taſte.

This yaourt or leban is ſo valuable an article with the people, and is looked upon with ſuch high conſideration, as to give riſe to a ſtory of their firſt having received it from the hand of an angel, who taught Abraham how to make it, and that the angel brought a pot of it to Hagar.

With reſpect to the knowledge the Tartars had of extracting a ſpirit from this kumiſs, we are informed by Marcus Paulus, that it was known to them even in the thirteenth century; to this ſpirit they gave the name of arki or ariki. We are informed by Pallas, that when they are in want of mare's milk they uſe that of the cow; but they prefer the kumiſs, from it's containing a greater quantity of ſpirit, viz. one third of the whole; whilſt the milk of the cow only affords two ninths. The Kalmuc Tartars call that from the mare tſchigan, and that from the cow arjan or airer. This report of Pallas is confirmed by Beretſhonſhys, who accompanied Lepechin and ſome other academicians in their travels into Siberia and Tartary, and who publiſhed in 1778, at Straſburg, a diſſertation on the ardent ſpirit to be obtained from milk. As authors have differed reſpecting the abſence or preſence of ſome of the component parts of milk in making this ſpirit, Oſeretſkowſky made ſome experiments on this ſubject, and found that the milk muſt not be deprived of any of it's parts; he found, that the milk when deprived of it's buttter gave no ſpirit, neither of itſelf, nor by the addition of a fermenting ſubſtance; that imperfectly deprived of it, and likewiſe of moſt of it's caſeous matter, the whey afforded very little ſpirit after the acetous fermentation; and, on the contrary, milk that had been fermented by conſtant agitation in a cloſe veſſel, without any alteration of it's parts, produced the moſt ſpirit; and that a ſtill larger proportion was obtained, if the fermented milk was not immediately diſtilled, but left to ſtand ſome time, as it became much milder reſpecting it's acid. He took ſix pounds of cow's milk, put it into a glaſs with a narrow mouth, let it remain in it two months, ſhaking it well two or three times a day. During the agitation a great quantity of an aerial gas was extricated, and on the ſurface there was a white maſs collected, full of air bladders, which diſappeared on ſhaking; at length, the cream united again with the caſeous parts and whey, and perfectly reſembled freſh drawn milk in colour. There being no more air, the odour was very ſour, and the liquor not unpleaſant, but ſtrongly acetous and ſomewhat vinous to the taſte. He then let this lacteal wine ſtand a fortnight longer, in a well cloſed bottle, when he found it was become much milder, and approached the lacteal ſpirit in taſte. By repeated diſtillation he obtained three ounces of a very ſtrong ſpirit, which, on inflammation, loſt one half. It is now found that all milks contain more or leſs of this ſpirit; and it was remarked by Macquer, long ago, that the human milk on ſtanding acquires in a ſhort time a vinous ſmell which is not unpleaſant; and Voltelen has found, that on diſtillation, the human milk affords a much greater quantity of a gaſeous fluid than any other milk.

General reflections.

From the analyſis and phyſical properties of the different ſorts of milk, it appears, that their odour, ſavour, and conſiſtence, are ſuch nice diſtinguiſhing characters, as to make it very difficult to lay hold of them, unleſs by a further compariſon. They all poſſeſs volatile principles, the nature of which we are ignorant of; for neither the odoriferous particles, nor thoſe which give them flavour, have been obtained, unleſs in combination with water. From the difference, however, of their ſtriking the organs of ſenſe, we may conclude, that they muſt neceſſarily differ amongſt themſelves. They all afford *cream*; but this, which is thick in the milk of the cow, is ſtill more ſo in the goat's and ſheep's; whilſt in human, aſs's, and mare's milk, Parmentier always found it leſs abundant and more fluid, which make them approach nearer to each other, preſerving, however, ſhades by which they may be diſtinguiſhed.

In the various kinds of *butter* the differences are ſtill more marked than in the cream; that of the cow, for inſtance, ſeparates more eaſily, and once ſeparated, is no longer miſcible either with milk or water; in conſiſtence it is generally pretty firm; the butter of the goat ſeparates with the ſame facility and agrees with it in conſiſtence, but it is conſtantly more inſipid in taſte; whilſt the butter of the ſheep, although abundant, remains ſoft in all weather. As to the three other milks, although Parmentier was not able to extract the butter, he has no doubt of it's exiſtence.

With reſpect to the *caſeous matter*, it differs ſtill more; that of the cow firſt appears in a gelatinous form, being as yet impregnated with the whey in which it was formed; when ſeparated, it becomes in ſome meaſure fibrous. The curd of the goat has nearly the ſame properties; whilſt that of the ſheep is always of a viſcous conſiſtence. In the human milk, the caſeous matter never ſeparates ſpontaneouſly in a homogeneous maſs; it is always in a divided ſtate, preſerving after it is collected a ſort of creamy unctuoſity. That of the aſs has indeed a gelatinous appearance, but deprived of it's whey it loſes it in ſome meaſure; whilſt the curd of the mare reſembles it by forming in a maſs, but with greater difficulty.

It appears, therefore, a general rule may be eſtabliſhed, viz. that every ſpecies of milk incapable of furniſhing caſeous matter under a gelatinous form by ordinary means, will never afford butter to be compared to that of milk, the coagulum of which is well characteriſed; as is evident from the human, aſs's, and mare's milks, which coagulate ill, and afford butter with difficulty; whilſt thoſe of the cow, goat, and ſheep, which coagulate well, always produce firm butter, and with the greateſt facility.

With reſpect to the *ſerum* of theſe different milks, it varies as to quantity and ſavour, and may be obtained clear and colourleſs when no recourſe is had to fermentation or the fire. It is afforded in large quantity by the aſs's, mare's, and human milks, whilſt the goat's and cow's give leſs, and the ſheep's leaſt of all.

It appears, from Parmentier's experiments, that of all the eſſential parts which conſtitute the different milks, the ſaccharine part was the only one in which no difference could be obſerved; it had the ſame ſavour and colour in all, and may be properly denominated the *eſſential ſalt of milk.*

With reſpect to the milk of animals under diſeaſe, although it is conſtantly undergoing changes in health, theſe changes are infinitely more ſenſible when they are ill; but it appears, the moſt curious circumſtance is, that the alteration principally takes place in the caſeous part, which is the only part in milk that is really animalized;

and it appears further that what happens to milk, takes place equally in all animal fluids; thus in the blood, the bile, and the urine of an animal under diſeaſe, it is always the lymphatic part that undergoes a ſpecies of decompoſition; whilſt the ſerous and ſaline parts ſuffer no change. Parmentier obſerved, that the change in the caſeous part of milk varied according to the ſpecies of the diſeaſe.

From the experiments of Stipriaan on the above milks, we have the following obſervations: he found the milk of the aſs to be the moſt *aqueous*; then followed that of the mare, the human, the cow's, the goat's, and leaſt of all was that of the ſheep.

With reſpect to *cream*, the ſheep's afforded the moſt; then the human, the goat's, the cow's, and the aſs's and mare's gave the leaſt quantity.

Of *butter*, the ſheep's produced the largeſt quantity; then the goat's, the cow's, and the human milk.

Of *cheeſe*, the ſheep's had the preference; then the goat's, the cow's, aſs's, and the human milk, whilſt the mare's gave the leaſt quantity.

The moſt *ſugar* was extracted from the milk of the mare; then followed the human, the aſs's, and the goat's, the ſheep's gave leſs, and the cow's leaſt of all.

Such are the obſervations of chemiſts on the milks of various animals; from the analyſis of which, Parmentier has divided them into *two claſſes*; *the one claſs* comprehends thoſe milks which abound in ſerous and ſaline parts, as that of the aſs, the mare's, and the human; *the other*, thoſe which are rich in caſeous and butyraceous parts, as thoſe of the cow, the goat, and the ſheep; "in ſhort," ſays that experienced chemiſt, "it marks the ſpecies which is to be preferred, in ſuch and ſuch circumſtances, in order to paſs from one kind to another, and even ſucceſſively from the uſe of one milk to another, without being expoſed to any inconveniency."

Whatever may have been the different opinions of authors with reſpect to the means of perfecting the butyraceous and caſeous parts of milk; there is no doubt but that the means of increaſing it's quantity, and of making it excel in quality, is to nouriſh the animals well from which it is drawn; by keeping them clean; often renewing their litter; milking them at regular periods; and procuring for them the beſt food. The experiments of Parmentier have, likewiſe, proved to him, that milk always participates of the individual from which it is drawn, as well as of the aliments which have ſerved for it's nouriſhment. It has long been obſerved, that plants communicate to the milk their particular ſavour and odour; thus, bitter plants are ſaid to give it their bitterneſs; the garlic it's ſtrong and diſagreeable taſte; that colour is given to it by ſome plants, as the ſaffron; and their purgative quality by others; that Indian corn gives it a ſweet ſavour; and the more aqueous plants render it aqueous and inſipid. It is, however, very well known, that all plants do not contain ſugar in the ſame quantity, whilſt many do not contain it at all; which ſeems to prove, that from it's conſtancy in the milk of animals, the animal ſyſtem, as well as vegetable, has the property of producing it. "But if the ſavour of the milk," ſays Parmentier, "(independently of the peculiar nature of the animal), be owing to the reunion of the different principles that conſtitute this fluid; it is not leſs true, that theſe principles receive, on the part of vegetables, characters which are in ſome ſort indelible. If plants contain, for example, mucous matter in abundance, the milk will give a great deal of caſeous matter, and it's ſavour will be inſipid or ſweet. If, on the contrary, they are very aromatic, the butter will be ſapid, from the affinity of the *eſprit recteur* with the oily matter. In the ſame manner the milk will be coloured, if the plants contain a colouring matter, ſoluble in one of the principles; and it will abound in whey or ſerum, if the plants contain much humidity. In ſhort, all the products will be more fine, more ſolid, and more perfect, according to the tenuity of the oily, mucilaginous ſubſtances, and to the coriaceous, hard, and fibrous ſtate of the plants, which concur to their formation. This being admitted, it is eaſy to ſee, why the moſt perfect butter, and the moſt eſteemed cheeſes, are made from milk of cattle nouriſhed in meadows where many odoriferous plants grow; and when theſe meadows have loſt, by exſiccation, their perfume, and their ſuperabundant humidity, they give a leſs delicate and more firm butter; whilſt cows, furniſhed ſimply with the ſtalk and leaves of the maize, give always a ſweet milk, an inſipid and firm butter, on account of the inſolubility of the saccharine body in the butter, of the abſence of the aromatic part, and of the ſolidity of the vegetable. It will further explain, why the milk of the cow fed by potatoe tops, which are more aqueous than maize, gives equally an inſipid butter, but of a leſs firm conſiſtence; why the cruciform plants communicate a ſtrong taſte to butter, whilſt the whey is almoſt inſipid; in ſhort, why cows, that feed in moiſt places, give milk leſs rich than thoſe feeding on high and open paſtures. If, therefore, we wiſh to make the butter and cheeſe of cows fed in the firſt paſture more perfect, ſome aromatic plants muſt be added to their common food; whilſt ſucculent and inodorous plants muſt be added to thoſe nouriſhed in the ſecond; for good paſtures depend as much on the ſoil and aſpect as on the variety of plants of which they are compoſed. To conclude; the foundation of the opinion of thoſe authors, who ſay, that manipulation does every thing reſpecting the quality and the quantity of butter and cheeſe, and the paſtures nothing, is totally overthrown by reaſon and experience; for the influence of vegetables on the nature and quantity of theſe two products are evident, as well as that of the proceſſes employed to facilitate them."

Jacquin's Elements of Chemiſtry, p. 311. London, 1799.—Macquer's Chemiſches Wœrterbuch, von. G. Leonhardi, art. milch.—Anderſon's Eſſays on Agriculture, vol. 2. p. 70.—Beckmann's Beytræge, 3 tom. Leipſig, art. butter, 1783.—Pliny's Natural Hiſtory, London, 1634.—T. Voltelen de Lacte Humano Obſervat. Chimicæ. Lips. 1775.—J. Bergius Verſuche mit Frauenmilch, tranſlated from the Swediſh, in Crell's neueſt. Entd. 1. ſ. 57.—G. Aug. Lichtenſtein's abhandl. vom. Milchzucker, Brauns. 1775.—Annal. de Chim. tom. 10. p. 206.—A memoir by Dr. Grieve in the Tranſ. of the Royal Society of Edinburgh, for 1788.—Sur le Sucre de Lait naturel par M. Jahrig. Journ. de phys. ſem. 2. p. 368, 1791.—Eton's Survey of the Turkiſh Empire.—Rouelle in the Journ. de Médecine, mar. p. 250, 1773.—Scheele's works.—Hermbſtadt's chem. Unterſuch. des Milchzuckers in Crell's n. Entd. tom. 5.—Mémoir pour determiner par l'examen comparé des proprietes phyſiq. & chimiques la nature des différens laits, &c. par. Meſſrs. Parmentier and Deyeux, ſem. 2. p. 361 415. Journ. de phyſique, 1790.—Obſervations ſur les caves & fromages de Roquefort, par M. Chaptal, an. de ch. p. 31. tom. 4.—Sur le beurre & la crême du lait de vache, par. M. Fourcroy, ibid. p. 166. tom. 7.—Obſervations on the properties commonly attributed by medical writers to human milk, &c. by Jos. Clarke, M. D. p. 171. Tranſ. of the Royal Iriſh Acad. for 1788.—Experiments des Meſſrs. Stipriaan, Liviſcius et D. Bondt, in the Mém. de la Societ. de Méd. à Paris, 1787 and 1788, tranſlated into German in Crell's Chemiſche Annalen, ſ. 8. p. 138. 1794.

GASTRIC JUICE.

A menſtruum of a peculiar kind.

THE gaſtric juice, when pure and in a healthy ſtate, is a thin, tranſparent, uninflammable fluid, ſecreted into the ſtomachs of animals by certain glands or veſſels ſituate in the coats of that viſcus; and forming a menſtruum of a peculiar kind, for the digeſtion of the various aliments.

Neither acid nor alkaline.

Action of regents upon it.

It has no ſmell, is of a weak ſaline taſte, and colourleſs as water. It is neither acid nor alkaline, conſequently does not change the colour of litmus or of violets. It unites perfectly with water. When mixed with alcohol, an animal portion of it is precipitated in the form of a coagulum, in ſmall quantity; by Plenck ſaid to be of an albuminous nature, by others to be gelatinous.

Does not become putrid.

It neither effervesces with acids nor with alkalis, nor is coagulated by them. It is more difficultly frozen than water. It undergoes neither the acetous nor putrid fermentation.

Curdles milk.

It curdles the caſeous part of milk. It diſſolves vegetable or animal matter, or both, according to the nouriſhment of the animal. From the experiments of Carminati, it diſſolves iron, crude antimony, the flowers of zinc, and corroſive ſublimate; but has no effect on copper, cinnabar, or ſulphur. It is highly antiſeptic.

Diſtilled.

It is eaſily evaporated, and by a gentle diſtillation in a water bath, it affords nothing but water, which is neither acid nor alkaline; the remainder is of an animal nature, containing a little muriat of ſoda; hence, the gaſtric juice when pure, and taken from the human body in a ſtate of health, is compoſed of water, muriat of ſoda, and an animal ſubſtance, which, according to ſome, affords phoſphat of *ammonia*. In the ſtate in which it is generally found in the ſtomachs of animals, it varies more or leſs in it's properties, not only in the ſame animal at different times, but in thoſe whoſe organs of digeſtion are different in their ſtructure, and in theſe the variety is ſtill greater. Much likewiſe depends on the nouriſhment, powers of digeſtion, and other circumſtances difficult to explain. Thus, it may be generally laid down as a rule, that the gaſtric juice in the *carnivorous* and *graminivorous* claſſes of animals, which have only one ſtomach, is acid, and colours the ſyrup of violets red.

When impure is found in ſome animals acid.

In the *omnivorous*, ſuch as man, whoſe food is compoſed both of vegetable and animal diet, it is neutral.

In others neutral.

In the *graminivorous* ruminating animals with four ſtomachs, and particularly in the adults, it ſoon becomes putrid, and colours the ſyrup of violets green.

In others alkaline.

It appears, however, from the experiments which have been made on the different gaſtric juices, that they have all of them three properties in common, viz. they diſſolve vegetable and animal ſubſtances with more or leſs facility; coagulate the caſeous part of milk; and poſſeſs an antiſeptic quality.

A more minute examination of the properties of the different gaſtric juices has been made by Carminati, Brugnatelli, and Macquart.

According to Carminati, the gaſtric juice of the *carnivorous* claſs of birds, ſuch as falcons, hawks, herons, and owls, differ both in denſity and colour; it has, however, in all, a bitter ſaline taſte, is evidently acid, and examined by the moiſt way, beſides water, contains a dark coloured very bitter reſinous matter, with a penetrating and peculiar odour; an animal ſubſtance of the ſame colour, very little ammoniacal, and a greater quantity of marine ſalt. In the dry way, the products of diſ-

Experiments on the gaſtric juice of the carnivorous claſs.

tillation were much water, an acid, a few drops of an acrid, fat oil, adhering to the neck of the receiver, with a ſaline ſubſtance affording the ſmell of ammonia. The caput mortuum gave cryſtals of marine ſalt, and the incinerated aſhes a little iron and ſome calcareous earth.

The experiments of Brugnatelli on the gaſtric juice of the owl agree pretty much with thoſe of Carminati; he found it to be leſs aqueous than that of animals which feed on vegetables, of a dark colour, turbid, and a ſharp bitter taſte, and a penetrating, acid, rancid ſmell; he found it contained likewiſe a reſinous matter, a free acid, and a little common ſalt united to an animal matter; it is very antſeptic. Carminati found the gaſtric juice of graminivorous nonruminating animals, as the rabbit, &c. to have the ſame properties, and to be ſimilar in it's contents to that of the carnivorous.

Omnivorous claſs.

With reſpect to the *omnivorous* claſs, ſuch as man, cats, dogs, crows, &c. he obſerved that their gaſtric juice was neutral when nouriſhed with fleſh and vegetables, but if only with fleſh, it became perfectly ſimilar to the carnivorous gaſtric juice; on diſtillation, he obtained a water that ſometimes became alkaline, owing as he thought to it's being impure, for when freſh the water was inſipid; the reſt was a phlegm, a little black and acid oil, and the caput mortuum reſembled that of the preceding claſs.

Brugnatelli found an acid in all animals of that claſs, or in cats and blackbirds, &c. and having fed them with fleſh a few days, it reſembled that of the owl. He kept an owl for ten days on vegetables; it, however, did not loſe it's acid, but only became more aqueous. He attributes it to it's drinking water, which is not the caſe when fed on fleſh. He found the gaſtric juice acid in the granivorous fowls, ſuch as pigeons, quails, ducks, hens, &c.

Scopoli triturated ſome gaſtric juice of the cow with cauſtic potaſh and quick lime, and he diſtinctly perceived an urinous and acid odour. It ſenſibly changed violet ſirup green; poured into a nitrous ſolution of ſilver, it afforded a precipitate that reſembled the muriat of ſilver. Two drachms ſlowly evaporated, left two grains of a grey matter, which had a diſagreeable odour, deliqueſced in the air, and did not effervefce with acids. On diſtillation, it afforded an empyreumatic phlegm, whilſt a white matter was attached to the ſide of the retort, which, when triturated with lime, manifeſted an urinous odour; the reſiduum had the conſiſtence of an extract, had an empyreumatic ſmell, ſaline taſte, bitter and nauſeous; it neither effervefced with acids nor alkalis, and put into a ſolution of potaſh, there aroſe a very penetrating odour of volatile alkali. He concludes that pure gaſtric juice is compoſed of a ſaponaceous and gelatinous animal ſubſtance, of ſal ammoniac, and of an earth ſimilar to that which all animal fluids afford. "Since it is evident," ſays Morveau, "that this chemiſt has only judged of the nature of the acid by the appearance of the ſaline precipitate of ſilver, much is wanting to make the proof ſufficient, ſince other acids likewiſe precipitate this metal. Theſe doubts are the more admiſſible, ſince the author carries the conſequences of theſe reſults to a greater length; he goes ſo far as even to ſuſpect that the muriatic acid is *the product of the vital power* in animals; he looks on the fact as proved, if the gaſtric juice of animals nouriſhed with vegetables likewiſe affords ſal ammoniac; and Spallanzani aſſures us, that after having fed five crows for fifteen days ſolely on vegetables, he found the gaſtric juice to afford likewiſe a precipitate of luna cornea." Other experiments are neceſſary, and better proofs required before ſo new a ſyſtem can be received, or before the nature of the acid can be determined, which, in the gaſtric juice, puts the ammonia into the ſtate of a neutral ammoniacal ſalt.

Graminivorous claſs.

The *graminivorous* ruminating claſs, according to Carminati, is compoſed of ſimilar principles to the preceding, if a portion of ammoniacal ſalt be excepted in the gaſtric juice, which he believes to be in reality acid. He has, however, found the gaſtric juice of lambs, ſheep, goats, and herbivorous calves, taken a long time from the living or dead animal, very often alkaline ſo as to effervefce with acids; but the alkali he looks upon as the product of the putrefaction of the herbs, which ſojourn a long time in the ſtomachs of theſe animals; he founds his opinion on the following obſervations: 1ſt. the gaſtric juice of theſe animals is often found acid. 2d. it is always ſo in ſucking calves, and even in the ox, after having faſted ſome time, or rather after a good and perfect digeſtion. 3d. freſh graſs digeſted in pure or ſalt water, at a heat between twenty-five and thirty of Reaumur, becomes alkaline in a few days. 4th. ſimilar graſs being plunged in the gaſtric juice of ruminating animals, whether acid or alkaline, the acid juice became alkaline in the ſpace of four days; and 5thly, the gaſtric juice of ſheep, which had faſted a long time, was found acid. On diſtillation, the gaſtric juice of this claſs at firſt afforded an alkaline, and afterward an acid water; when, on concentrating this water, he collected a little acid from it which he looks upon as an animal acid. It likewiſe afforded ſome ammoniacal ſalt, which, however, is not always the caſe, and an empyreumatic oil; the reſt was ſimilar to the preceding.

According to Brugnatelli, the gaſtric juice of this claſs, ſuch as the ſheep, &c. is found in all the four ſtomachs, but the pureſt in the firſt: it is very aqueous, in oppoſition to that of the carnivorous claſs, a little turbid, and of a pale earthy colour: it conſiſts of a great watery portion of volatile alkali, of an animal extractive matter, with a good deal of ſea ſalt: it is bitter, ſharp, and ſaline to the taſte: it eaſily putrifies in ſummer, and in four or five days ſmells like rotten eggs.

Macquart has likewiſe made ſome experiments on the gaſtric juice of the ox, the ſheep, and the calf. The juice from the ſtomach of the ox he collected when faſting; it ſmelled like ſtraw, to which was ſometimes added a reſemblance to muſk; each animal afforded one pound and half, which he filtered and preſerved in bottles for uſe, but it was impoſſible to procure it clear and tranſparent. He found on analyſis,

1ſt. That one pound four ounces gave ten grains of a lymphatic matter, having the ſame properties as that of blood.

2d. $16\frac{6}{7}$ of phoſphoric acid.

3d. 5 grains of phoſphat of lime.

4th. 2 ditto of reſin.

5th. 14 ditto of ſal ammoniac.

6th. 29 ditto of muriat of ſoda.

7th. And a ſmall quantity of extract remained difficult to appreciate.

8th. The quantity of water was one pound, three ounces, ſix drachms, and 67 grains and half.

Total 1 lb. 4 ounces.

The ſtomach of the ſheep contains from five to eight ounces of pure viſcous gaſtric juice, of a deep green colour, and more diſpoſed to putrefaction than that of the ox or calf; from this he ſeparated the lymph by means of heat; he found that volatile alkali diſcovered the preſence of the phoſphat of lime; that ſpirit of wine rendered the ſal ammoniac and reſin ſenſible; that lime, by the weight of the precipitate it affords, indicates that of the diſengaged phoſphoric acid; and laſtly, his analyſis procured the preſence of marine ſalt. One pound of this gaſtric juice afforded

Lymph	64 grains.
Phoſphat of lime ..	10
Muriat of ammonia	13.20
Reſin	10
Phoſphoric acid ..	10
Marine ſalt	13.18
Extract	2
Water	15℥ 3ʒ 62
Total	1lb.

Hence, according to Macquart, the gaſtric juices of the ox and ſheep are of the ſame nature; but the laſt contains more ſerum and extract, and is more liable to the putrid fermentation in conſequence.

The ſtomach of the calf Macquart found to contain from four to ſix ounces of gaſtric juice, always mixed with a reddiſh grey matter with much hair. When filtrated it has a light grey colour, precipitates lime water, and affords a white depoſit by the addition of volatile alkali. It begins to ferment in five or ſix days expoſed to a temperature of 20° of Reaumur. It then depoſits a white powder of a diſagreeable ſmell. It contained phoſphat of lime and ſulphat of lime; expoſed to a boiling heat, it depoſits but very little coagulated lymphatic matter. One pound of this gaſtric juice afforded

Lymph	4 grains
Dry jelly	24
Selenite	6
Phoſphat of lime	10
Sal ammoniac	12

Lactic acid	48 grains.
Marine ſalt	40
Phoſphoric acid	4

without reckoning the ſugar and the extract contained in the juice. Hence it appears that the gaſtric juice of the calf differs from both the preceding, by containing a greater quantity of gelatinous matter, ſugar, and ſelenite. The difference is greater from the lactic acid it contains, which is in great abundance. Macquart found, that the proportion of the principles in the gaſtric juices of animals varies from their individual ſtrength, their age, and more eſpecially from the nature of the climate, in which he agrees with other chemiſts; and he has determined that the gaſtric juice of ruminating animals contains the phoſphoric acid, and not one *ſui generis*, and in this he has been ſupported by Struve.

OF THE ACIDITY OF THE GASTRIC JUICE.

Acidity of the gaſtric juice.

THE property which rennet has of coagulating the caſeous part of milk was known in the time of Dioſcorides; and as it has been remarked that acids had the ſame effect, it was natural to ſuppoſe they would attribute this property in rennet to it's poſſeſſing an acid. Many celebrated writers have likewiſe remarked, that the gaſtric juice of carnivorous animals is acid. Thus Floyer found it acid in carnivorous birds; Marſigli, in the eagle; Viridet, in carnivorous fiſh; and Lorenzini in the crampfiſh; but all have attributed this acidity to the unnatural ſtate of the gaſtric juice. With reſpect to rennet, which is the dried ſtomach of the calf; it is the fourth ſtomach of the ruminating tribe only that poſſeſſes this quality.

The juice found in the craws of birds has not this property. Macquer looked upon it's coagulating property to ariſe from the remnant of ſour milky matter, which he thought was ſufficient to coagulate the milk. It is, however, now proved that this property ariſes from the nature of the gaſtric juice itſelf; that this virtue is communicated even to the coat of the ſtomach itſelf, and to a certain point to the neighbouring parts which are moſt impregnated with it. It therefore remains to examine whether this property ariſes from the gaſtric juice being an acid, or from it's own peculiar nature. Morveau digeſted at different times parts of the interior tunic of the ſtomach of the calf, both in hot and cold water, previouſly diſtilled; he then ponred ſome ſpirit of wine upon it, which occaſioned a precipitate, and he always found that the filtrated liquor ſenſibly changed blue water to a red. According to Scopoli, the human gaſtric juice is ſometimes acid, and at other times not; which is proved by the acid or inſipid eructations, either when faſting, or during the time of digeſtion. The gaſtric juice therefore, being found ſo very generally in a ſtate of acidity, Morveau has placed it in the French Encyclopédie amongſt the animal acids, under the name of the *gaſtric acid*, doubting at the ſame time whether it be an eſſential part of it's nature. From the experiments of Spallanzani, this acid quality depends on the aliments, for birds of prey never gave the leaſt ſign of any acidity; and the ſame may be ſaid of frogs, ſerpents, and fiſh. He found that when the gaſtric juice of crows afforded him ſigns of acidity, they had been nouriſhed on vegetables; and the ſame obſervation might be applied to dogs, graminivorous animals, and the gallinaceous claſs. Shells and coral were likewiſe rendered up by carnivorous birds, without having undergone the leaſt alteration, which would not have been the caſe if the juice had contained an acid. Spallanzani likewiſe ſwallowed calcareous ſubſtances encloſed in tubes, which he found were only diminiſhed when he uſed vegetable food or fruits; and that when he fed on animal food they were always untouched. The teſtimony of Goſſe of Geneva may likewiſe be adduced, for he was not able to ſuſtain any length of time the uſe of crude vegetables, from the frequency of the acid eructations they occaſioned. In ſhort, Monck, after having obſerved that calcined magneſia was not in any way ſoluble in the gaſtric juices of different animals, affirms, that he has ſeen the gaſtric juice vomited by a hypocondriac perſon to be acid, efferveſce ſtrongly with crabs eyes, and diſſolve two grains of calcined mganeſia.

Spallanzani is of opinion, that in it's natural ſtate the gaſtric juice is neither acid nor alkaline, but neutral. His reaſon for thinking ſo is, that the acid which is manifeſt at the beginning of digeſtion in the ſtomach of ſome animals, conſtantly diſappears toward the end of that proceſs, and is very inconſiderable; and that when gaſtric juices are poured into a ſolution of the carbonat of potaſh, there never ariſes any efferveſcence; which proves that they either contain no diſengaged acid, or that the acid is not ſufficiently powerful to diſplace the carbonic acid.

The difference in the reſult of the experiments of thoſe who have inveſtigated this liquor, it is evident, muſt have ariſen from the difficulty of procuring it in a pure and healthy ſtate, for it would appear that the acidity is owing entirely to the food. It is well known that vegetables, when expoſed to a heat equal to that of the ſtomach, are very prone to the acetous fermentation; and that on the contrary, animal food under the ſame circumſtances tends to the production of volatile alkali; and theſe will take place in proportion to the weakneſs of the ſtomach; or if the quantity of food taken in exceeds the power of the gaſtric juice to prevent them; for it is proved from experiment, that this juice when pure is much diſpoſed to counteract either, and in weak ſtomachs, ſuch as children, the contents are often ſour, as is eaſily known from the acid eructations and the uſe of magneſia. Likewiſe, that food in carnivorous animals, when taken in too great quantity, is very apt to tend toward the putrid fermentation, is evident from the putrid eructations, and the diſagreeable ſmell of dogs and other animals of that claſs, which are apt to eat voraciouſly. It would ſeem, therefore, that both the acid and the alkali, when found in a ſeparate ſtate in the gaſtric juice, proceed from theſe cauſes; and the ſame thing happens in vegeto-carnivorous animals, where the neutral ſalts are found. To theſe it may be added, that it's not being always found to have acid properties, is a proof that they are only accidental, and like the alkaline, only proceed from foreign cauſes; and that when found in a neutral ſtate, it does not appear to alter it's properties as an animal and vegetable menſtruum, which would be the caſe if it's powers depended on it's acidity. But the experiments of Fordyce and Hunter, appear to put the matter out of all doubt. Dr. Fordyce found, that when dogs had bread for their food, which is not their natural aliment, in about four hours after, an acid was diſcovered on examining that part which had paſſed into the beginning of the duodenum; but on changing the food for meat, no acid enſued. The ſame with reſpect to ſheep and cows, the natural food of which is vegetable; for the matter at the beginning of the duodenum in theſe animals ſhowed not the leaſt trace of acidity, as it neither changed the colour of red cherry juice, nor litmus, which are the moſt delicate teſts. Hunter, about the ſame time, found no acid in the previous or digeſtive ſtomach of rabbits, and other animals of the ſame kind.

Dr. Fordyce even found, that when the ſtomach was in perfect health and vigour, if putrid meat was conveyed into it, as being ſwallowed by a dog, it was rendered perfectly ſweet again. The inhabitants about the mouth of the Orange river, in Africa, live always on animal food, which is often putrid, yet they are ſtrong and healthy; and maggots that live upon and in putrid maſſes, are themſelves perfectly ſweet, and their fluids are entirely free from the leaſt taint of putrefaction.

METHODS OF PROCURING IT IN IT'S PURE STATE.

To procure the gaſtric juice in it's pure ſtate.

SINCE many errors may have ariſen from the difficulty of procuring the gaſtric juice in a pure ſtate, from it's being eaſily affected by acid or rancid ſubſtances taken into the ſtomach, or from it's admixture with the bile from the duodenum, many methods have been invented to procure it in a ſtate proper for experiments; three of which I ſhall deſcribe as being the leaſt liable to miſlead the chemiſt.

1ſt. method.

The *firſt* and moſt ſimple method is to take it after the death of the animal; and if previous to this, it be ſuffered to faſt for ſome time, it will not only be obtained in greater abundance, but the danger of any admixture of the aliments will be decreaſed. It was in this manner that Spallanzani obtained 37 ounces of gaſtric juice from the two firſt ſtomachs of a ſheep, after it's faſting two days; it was of a green colour, which might proceed from a ſmall quantity of graſs remaining there, and which is a proof how difficult it is to procure it perfectly free from other ſubſtances. He likewiſe opened ſome young crows that had not flown, and found about half a ſpoonful, which was more than he could get from adults. This method, however, is very cruel, and will ſcarcely be attempted by the more humane philoſopher, whilſt he has other means in his power.

2d. method.

A *ſecond* method is by means of ſponges. Reaumur made uſe of them without any defence, but Spallanzani placed them in little thin metallic tubes, pierced with ſmall holes; theſe he made the animals ſwallow. He obliged ſome crows to take each eight of theſe tubes, ſucceſſively, when, in the ſpace of three hours and a half, they were vomited up again. He collected from five crows 481 grains of gaſtric juice, of a yellow, tranſparent, dirty colour, ſaline and bitter to the taſte, affording very little ſediment if the bird had faſted, and which although expoſed to the air for ſeveral hours, evaporated very little, and extinguiſhed flame. This yellow colour and bitter taſte moſt probably aroſe from the bile, as well as the reſinous matter which is found in the gaſtric juice.

3d. method. A *third* method is to procure it in the morning, faſting, by exciting vomiting; in this manner, Spallanzani procured it twice, by irritating his throat with his two forefingers. At one time he got by this means one ounce thirty-two grains of a viſcous, foamy liquor, which, after having depoſited a ſlight ſediment, became as limpid as water; it was without colour, of a ſaline taſte, without any bitterneſs, uninflammable, eaſily evaporated on the coals in an open veſſel, but in a cloſe one kept during a month in a very hot Italian ſummer, without either change of taſte or odour; the pain, however, which he ſuffered from the irritation, prevented him from trying the experiment a third time; and Scopoli has remarked, that by this means only, the more fluid parts are obtained, as the thicker portion remains attached to the bottom of the ſtomach, and is only to be procured by the more powerful emetics, ſuch as tartar emetic, &c. A more eaſy and profitable way of exciting vomiting, is that purſued by Goſſe. This eſtimable philoſopher has the power of rendering the contents of his ſtomach by ſwallowing air, which acts as an emetic; by which means he can procure the gaſtric juice in a much purer ſtate than by diſſections. To this it may be added, that Spallanzani has remarked, that the eagle renders a conſiderable quantity of gaſtric juice ſpontaneouſly, in a morning when faſting, exempt from foreign matter, of an aſh colour, nearly as fluid as water; it is ſaline, bitter, uninflammable, and has the ſame odour as other gaſtric fluids; he procured about ſix drachms of it every day, by placing a glaſs veſſel before the bird. Such are the principal methods by which this fluid may be obtained in as pure a ſtate as it's nature and ſituation will admit of; but there is reaſon to believe, that the mucus and ſaliva which are conſtantly mixing with it in the ſtomach may alter it's properties, whilſt the bile may be the cauſe of it's reſinous bitter taſte and yellow colour, which it is ſometimes known to poſſeſs.

Experiments upon the gaſtric juice in the ſtomach.

Beſides the methods juſt related of procuring this fluid for the ſake of experiments out of the body, others have been invented by which different experiments have been made on the powers of this fluid, whilſt it remains in the ſtomach, by which it's action on different ſubſtances may be better known, perhaps, than in any other ſituation, and when extracted from it's natural viſcus. This was firſt introduced by Reaumur, who forced ſheep to ſwallow ſmall tubes of metal filled with graſs and other herbs. It was followed by Spallanzani, who has employed the ſame method on a great number of different animals. The tubes were filled with the food peculiar to the animal, or with other ſubſtances, and were examined either on being rendered by the anus, or by exciting vomiting after a given time, or by opening the animal; whilſt ſome of the birds vomited them ſpontaneouſly in a few hours after having taken them. Spallanzani and Goſſe tried theſe methods on themſelves; The firſt began by ſwallowing ſmall purſes of roaſted or raw fleſh, or filled with bread, &c. Afterward he took ſmall cylinders of wood, pierced with holes, and covered over with linen;

but with reſpect to Goſſe, from the facility of rendering them at pleaſure, he was able to ſwallow different ſubſtances, to keep them as long in his ſtomach as he thought neceſſary, then reſtore them up again to obſerve and compare the progreſs of digeſtion; and he has made ſo many experiments on vegetable and animal matters, as to be able to form them into different claſſes, viz. Thoſe ſubſtances which appeared to him indigeſtible; thoſe in part digeſted; thoſe of eaſy digeſtion; thoſe which haſtened digeſtion; and thoſe which prevented or diminiſhed it.

It is ſuppoſed alſo by Brugnatelli, that the white matter which is generally found in large quantity in the excrements of carnivorous birds, and which differs very much in conſiſtence, which is ſoluble in water, and gives a ſtraw coloured liquor, is a portion of gaſtric juice, and may be of uſe in experiments. Such are the methods employed in experiments on the gaſtric fluid.

ANTISEPTIC QUALITY OF GASTRIC JUICE.

It's antiſeptic quality.

It has been obſerved that the gaſtric juice poſſeſſes an antiſeptic quality, by which it not only preſerves itſelf from putrefaction, but ſubſtances which are put into it. Various experiments on this power of the juice has been made, amongſt which the principal are thoſe by Jurine, Carminati, and Spallanzani. We are informed by Carminati, that the gaſtric juice of *carnivorous animals* was placed in veſſels expoſed to the air and heat of different ſeaſons; and that it always kept good and free from putridity until it became perfectly exſiccated. That when

In carnivorous animals.

this gaſtric juice was mixed with blood, or poured in different quantities on freſh and corrupt meats, it afforded various proofs of it's antiſeptic quality, either by preſerving them from corruption, or in correcting it after it had taken place; and it's action is the more certain and ſudden, the greater the quantity of the gaſtric juice employed, relative to the ſubſtance to which it is added.

Spallanzani has likewiſe proved the antiſeptic power of the gaſtric juice. He found that to produce artificial digeſtion, little or no ſolution takes place, unleſs the gaſtric fluid employed be expoſed to a briſk heat, but this heat is not neceſſary for it to retain it's antiſeptic powers. He found that the gaſtric juice of the crow and dog preſerved veal and mutton 37 days in winter, without it's being either conſumed or putrid; whilſt the ſame meats immerſed in water emitted a fetid ſmell on the 7th, and about the 30th day were changed into a very offenſive liquamen. Yet the gaſtric juice loſes at laſt it's antiſeptic quality, even though kept in phials perfectly well ſtopped, but it never becomes putrid itſelf. He found that fleſh which had an inſupportable ſtench when put into the gaſtric fluids of the dog, crow, owl and eagle, during the month of March, at a temperature of from eight to twelve of Reaumur, kept twenty five days, and was ſomewhat diminiſhed in ſmell, but not the leaſt diſſolved. That fowl and pigeon, in which putrefaction was far advanced, in the gaſtric fluid of a dog and falcon, in the month of June, was reduced to a jelly in 37 hours, and had loſt moſt of their diſguſting ſmell: hence heat is neceſſary in this caſe; and he found that fleſh which was become putrid in the craw of a cockerel, loſt it on arriving in the ſtomach. Animals of cold blood he found much longer in correcting the putrefaction of fleſh, from their ſlow digeſtive powers. Hence it appears from theſe experiments, that the various claſſes of animals, and man among the reſt, are endowed with the power not only of checking the putrefaction of ſubſtances in the ſtomach, but alſo of correcting them when already putrid. It is an antiſeptic, however, which differs from other ſubſtances poſſeſſing that property; for they, while they keep away putrefaction, preſerve or reſtore the coheſion of the parts, whilſt the gaſtric fluid, being at once an antiſeptic and ſolvent, preſerves or corrects putrefaction by reducing bodies.

From this antiſeptic quality, the diſguſting manners of theſe animals, who delight in corrupted and putrid ſubſtances, onght no longer to excite ſurpriſe, for the food, however putrid, muſt be totally changed before it is converted into nutriment and animalized. In this manner the multitude of loathſome inſects and worms that feed on decayed carcaſes, and of birds and quadrupeds, ſuch as the crow, the kite, the vulture, the jackal and the hyena, that ſeem to find a pleaſure in tainted fleſh, may devour their ſavoury morſels; and whilſt other animals are flying from the miaſmata ariſing from ſuch putrid bodies, theſe may enjoy their abominable repaſts with impunity.

Omnivorous.

In *omnivorous* animals, Carminati obſerved the ſame or nearly the ſame power in their gaſtric juice, as in the preceding.

Graminivorous.

Graminivorous, ruminating, and nonruminating animals, were found poſſeſſed of the ſame antiſeptic quality in their gaſtric juice, as, the others when it was acid; but when alkaline, it corrupts very ſoon, and more or leſs ſo according as the heat is greater or leſs, and it's alcaleſcency more or leſs ſtrong.

We are informed by Jurine, that the gaſtric juice of the ox, in the common temperature, kept inodorous about 30 hours, that at the end of 48, it had contracted a fetid odour; mixed with fleſh, it corrupted in 8 hours.

In an ice houſe, and the bottle ſtopped, it kept 14 days without change. It may be obſerved, that from this antiſeptic quality, ſome phyſicians have imagined that the gaſtric juice might be of uſe as remedies whether externally or internally applied.

APPLICATION OF THE GASTRIC JUICE IN DISEASES.

The gaſtric juice uſed as a medicine.

Jurine, of Geneva, Foggia and Carminati, have tried the effects of this liquor in different diſeaſes, and with various effects. We are informed by the firſt phyſician, that, when applied *externally*, 1ſt. the gaſtric juice has the property of curing certainly and immediately the pains which ariſe from bad ulcers.

2d. That it ſtimulates and deſtroys diſeaſed fleſh, and ſoftens the edges of callous ulcers.

3d. That it diſſipates diſagreeable and putrid odours ariſing from diſeaſed parts.

4th. It diminiſhes exceſſive ſuppuration, and gives it a healthy appearance.

5th. It accelerates the cicatrix. The experiments of Carminati appear to ſupport thoſe of Jurine; he found that the gaſtric juice of rooks, and of the Royſton crow, kept omnivorous by nouriſhing them with fleſh and vegetables; perfectly cured old fetid ulcers, after having been bathed with it two or three times a day; that it produced a ſenſation of heat during the two or three firſt days of it's application. He found the gaſtric juice of carnivorous animals poſſeſſed this property in an eminent degree, and although the heat it produces is greater than that from the crow, the cure is much quicker. He found it of great uſe in bad venereal ulcers, in ſtopping the progreſs of gangrene, and in rendering the ichorous humour of the cancer more mild, taking away it's fetid odour, and diminiſhing the ſhooting pains of that diſeaſe. The experiments of Foggia ſupport thoſe of Jurine, and the great beneficial effects of the application of the gaſtric juice of graminivorous animals in the cure of ulcers is aſſerted by Dr. Harneſs. He has found it to ſucceed in more than 100 inſtances, where ſphacelus had occurred; and teſtimonies of it's peculiar good effects in ſimilar caſes are given by Jones, a ſurgeon to the naval hoſpital at Baſtia, and Read and Buck, two of his principal aſſiſtants. An inſtance of the cure of an ulcer by Dr. Harneſs is the following. Thomas Corben, boatſwain of the Egmont, on the 31ſt of July, 1796, had an ulcer on the right leg, ſix inches in length, and four in breadth; the margin of the ſurrounding integuments, with the much greater portion of the ſurface of the ulcer, were in a ſphacelous ſtate. The diſcharge was ſo acrid as to deſtroy every part it came into contact with, and it had inſinuated itſelf through the whole length of the gaſtrocnemius and ſoleus muſcles. The whole extremity was very tenſe, and the health of the patient much impaired. He had recourſe to the gaſtric juice of a bullock killed for the uſe of the ſhips, from which three pints of fluid were obtained. The ſurface of the ulcer was waſhed with it, and it was injected by a ſyringe into the ſinuſes, and ſuperficial dreſſings of lint applied. The third day after this application was begun, upon removing the dreſſings, the whole of the ſphacelated parts came away, and expoſed a large portion of the tibia, in two places. To theſe, lint dipped in the gaſtric juice was applied, which not only appeared to prevent diſcoloration and exfoliation, the uſual attendants; but, on the contrary, in the courſe of eight days the parts thus expoſed were covered with granulations, and at the expiration of fourteen days, the whole of the ſoft parts were perfectly reunited, and the ſurface of the ulcers reduced to a ſore of about two inches and half diameter, with granulations ſmall, compact, and of a beautiful fluid colour. Nov. 10, it was perfectly healed, and the patient attended to the duties of the ſhip. He took Peruvian bark, and uſed lemons and onions during the cure.

Uſed *internally* in indigeſtion, ſuch as in vomitings of acid and black matter after eating, and in other diſeaſes where the gaſtric juice of the ſtomach had loſt it's energy, Carminati found it of great uſe. The doſe was one ounce of freſh juice from the ruminating claſs, taken daily. Where the organ itſelf was affected, it was of no uſe. The gaſtric juice of carnivorous animals he found to be too irritating to an ulcer of the ſtomach, until it had been diluted with water. He likewiſe cured intermittents with it, and raiſed the doſe to three ounces in the day. He obſerves that the juice of herbivorous ruminating animals, when acid, may be ſubſtituted for that of the carnivorous claſs, and is more eaſily procured.

We are informed, that Carminati was capable of imitating the gaſtric juice of the carnivorous claſs; he digeſted for this purpoſe two drachms of freſh veal in one ounce of ſpring water, and added five grains of common ſalt; it was expoſed to the heat of about 100° of Fahrenheit for ſixteen hours, and the liquor was then decanted. By repeated digeſtion with freſh fleſh, he found it became much ſtronger and more ſimilar to the natural gaſtric juice.

According to Struve, who ſays that the phoſphoric acid and volatile alkali are the two eſſential principles of the gaſtric juice, a liquor may be made which produces a ſimilar effect upon aliments.

DIGESTION.

If we look back into antiquity, we ſhall find that the earlieſt opinion on the cauſe of digeſtion was, that of putridity. It was by this proceſs that both Hippocrates and Empedocles ſuppoſed the food when taken into the ſtomach to be reduced to a proper ſtate for the ſupport of the animal ſyſtem.

Hippocrates and Empedocles.

Galen.

Galen and his diſciples conceived an idea that it was brought about by heat.

Van Helmont.

Van Helmont, whoſe wild conjectures can only be accounted for by the ſpirit and enthuſiaſm of alchemy, which raged in his time, attributed digeſtion to the vital energy of the ſoul, which reſided, as he thought, in the ſtomach.

Grew and Santarelli.

Grew and Santarelli were of opinion, that the ſpirits which are poured forth from the nerves of the ſtomach ſerved for the concoction of the food.

Boerhaave.

Boerhaave, who has in reality only attempted to reconcile the variety of opinions that had been propoſed before him, ſuppoſes there are two principal agents in this vital function, viz. the different fluids that are collected in the ſtomach, and the mechanical action of that organ. The ſecondary agents, he ſuppoſed, are heat, air, the nervous fluid, the remains of the food, and an incipient fermentation, oppoſing it in the extenſive ſenſe in which it was conſidered before him. With reſpect to the gaſtric fluid, his ideas appear to be indeterminate, and unſettled; he, however, conceived that it's action on the food was merely as a ſimple diluent, like water, when heated to the ſame temperature. He had no ſuſpicion of it's being a ſolvent, or that it was capable of acting upon the more tenacious and hard ſubſtances that were taken in as food.

According to Pringle and Macbride, digeſtion is carried on by a complete fermentative proceſs. The food divided by maſtication, and penetrated by the ſaliva, begins, as ſoon as it enters the ſtomach, to be agitated by that inteſtine motion which always accompanies fermentation; this motion is excited by the warmth of that viſcus, by the old remnants of the food, by the gaſtric fluid, and more particularly by the ſaliva, which is above all adapted to produce and promote this proceſs. They ſuppoſed that the firſt effect of this inteſtine commotion, is to raiſe the ſolid parts of the aliment to the ſurface of the gaſtric liquor, where they will be for ſome time ſuſtained by the air bubbles, which, on their ceaſing, muſt fall down again and be thoroughly incorporated with the fluids of the ſtomach. This mixture is rendered ſtill more complete by the periſtaltic motion, the alternate preſſure of the diaphragm and abdominal muſcles, and the continual pulſation of the adjacent large veſſels. In this ſtate the food paſſes into the ſmall inteſtines, where the fermentative motion produces ſtill greater changes by the aſſiſtance of the bile and pancreatic juices. It is then converted into chyle. Pringle and Macbride.

According to the opinion of Haller, the gaſtric juice is more or leſs acid in different animals; it's action on the food very much reſembles that of water, in which a little ſalt has been diſſolved, which, from experience, is known to poſſeſs a very great reſolvent power; and the conſequence is, that an incipient fermentation takes place which reduces the aliments to a pultaceous maſs. In animals that feed on ſeeds, this proceſs is aſſiſted by trituration. Theſe, with many other fanciful opinions, took place in their turn, when Cheſelden by chance happened to conjecture right, viz. that digeſtion was performed by ſome unknown menſtruum. This conjecture was confirmed by Reaumur and Spallanzani, who have proved the menſtruum to be the gaſtric juice by a number of experiments, a gene- Haller. Cheſelden. Reaumur and Spallanzani.

ral view of which it will be neceſſary to give. Spallanzani made his experiments by introducing certain ſubſtances, ſuch as raw vegetables, &c. encloſed in ſmall perforated tubes, and cauſing animals to ſwallow them; he then either deſtroyed the animal in order to examine it, or waited until it was vomited up. The animal kingdom may be divided into three kinds; thoſe whoſe ſtomachs are *muſcular*, *intermediate*, and *membranous*; the laſt claſs is infinitely more numerous than the two former.

Stomachs. Of animals with *muſcular* ſtomachs, ſuch as fowls, turkeys, ducks, geeſe, doves, pigeons, &c. the food is ſeeds, ſuch as wheat, barley, peaſe, &c. When it is taken ſpontaneouſly by theſe birds, it remains ſome time in the craw, where it is macerated and becomes ſofter; it is then conveyed into the ſtomach or gizzard, which is compoſed of very ſtrong muſcles, capable of grinding not only the grain it receives, but is of ſuch force as even to reduce ſmall pieces of glaſs, and blunt the points of needles; by this means the food is triturated and reduced very ſmall; it is then converted, by the gaſtric juice it meets with in this viſcus, into a pultaceous maſs called chyme. Spallanzani found, that the gaſtric juice of this claſs digeſts fleſh, and that they are for the moſt part both frugivorous and granivorous. He found it diſſolved raw fleſh, when bruiſed, in about two days; but when entire, four and ſometimes five days were neceſſary. It diſſolves grain only when bruiſed; hence, in the gallinaceous claſs, trituration and the gaſtric fluid in the gizzard, although Reaumur was of opinion it contained no menſtruum, mutually aſſiſt each other; the former, by breaking down the aliments in a mechanical way, prepares it for the latter, which penetrates it, deſtroys it's texture, diſſolves it's particles, and diſpoſes them to change their nature and become animalized. Spallanzani thinks, that this gaſtric fluid found in the gizzard proceeds chiefly from the œſophagus; the chyme he found to be a ſemifluid pultaceous maſs, of a whitiſh yellow colour. The tranſparency of this gaſtric juice, in a ſtate of purity, is little inferior to water, it is fluid, and a little bitteriſh and ſaline. It retains out of the body, when warm, the power of diſſolving animal and vegetable ſubſtances; but it muſt be freſh, for if kept in veſſels, particularly if open, it loſes it's efficacy; it muſt not have been uſed for experiments, and likewiſe a heat equal to that of the bird is neceſſary, otherwiſe it has no more effect than water.

The ruminating animals of the third claſs, ſuch as ſheep, oxen, &c. very much reſemble this claſs of birds in their manner of digeſting ſubſtances; in both, the gaſtric fluid requires an agent capable of breaking down the food, before it can diſſolve it. The hay and graſs, in the ruminating tribe, deſcend immediately into the firſt and ſecond ſtomachs in nearly the ſame ſtate as when firſt browzed. Here they are ſoftened by the juices, as feeds are in the craws of birds with gizzards; but as the ſtomachs of theſe quadrupeds have no triturating power, and the aliment requires trituration, it aſcends, in conſequence of a gentle ſtimulus to vomit, into the cavity of the mouth, where by means of rumination, it is put into the ſame ſtate previous to being digeſted by the gaſtric fluid, as happens to the food in the ſtomachs of granivorous fowls, after they have been properly triturated by the gaſtric *muſcles.*

Animals with *intermediate* ſtomachs, ſuch as ravens, crows, herons, &c. have muſcular ſtomachs, which are by no means equal in force to the ſtomachs of the firſt claſs, but much more ſo than thoſe of the third claſs. Theſe animals poſſeſs the privilege of returning ſubſtances they are incapable of digeſting, at leaſt every nine, and in general every two or three hours; they are omnivorous. Their gaſtric juice does not diſſolve whole ſeeds, they therefore bruiſe them with their beak and feet, and they are diſſolved in twenty-four hours; it ſoon diſſolves fleſh and cartilage, but not bone. The fluid in the œſophagus Spallanzani found inconſiderable as a menſtruum, when compared with that of the ſtomach, ſince the firſt was ſix hours in diſſolving two parts of fleſh, and the ſecond one hour only in diſſolving ſix parts; conſequently the œſophagal liquor in the craws of the gallinaceous, is different from that in this claſs. The *reſemblances* between the gaſtric fluids of theſe two claſſes may be reduced to five: firſt, theſe fluids, beſides being alike in colour, are always ſalt and bitter, which bitterneſs proceeds from the bile regurgitating through the pylorus into the ſtomach. Secondly, they are the immediate agents of digeſtion, both in the muſcular and intermediate ſtomachs, independently of trituration. Thirdly, the fluids act in the ſtomachs of theſe two claſſes of birds in the ſame manner, in the ſolution of the food; they firſt ſoften, and next convert the ſurface into a jelly, then produce the ſame effect on the intermediate parts, inſinuating themſelves gradually into it's ſubſtance until it is completely diſſolved. Fourthly, they do not entirely loſe their ſolvent power as ſoon as taken out of the ſtomach, provided they be heated to a proper degree. Fifthly, the origins whence theſe fluids ſpring are nearly the ſame, viz. the follicular glands with which their organs abound. With reſpect to the *differences*, they are in part reducible to the inferior efficacy of the gaſtric fluid in muſcular, to that of the ſame fluid in intermediate ſtomachs. The gaſtric juice of the firſt is incapable of diſſolving the ſame aliment that the latter readily diſſolves. Likewiſe, the food which each kind of gaſtric juice decompoſes and digeſts is ſooner ſubject to this change from that which belongs to intermediate ſtomachs; hence, artificial digeſtion ſucceeds much ſooner with the firſt than the ſecond. The ſame inefficacy that the gaſtric juices of birds with muſcular ſtomachs ſhows in the ſolution of aliments of a firm texture, extends alſo to their œſophagal juices in the ſolution of ſoft ſubſtances; notwithſtanding the latter are tolerably well decompoſed by the œſophagal juice of birds with intermediate ſtomachs. Another very ſtriking difference, is the prodigious force of trituration in muſcular ſtomachs, and the weakneſs of the other, which greatneſs of ſtrength was neceſſary in birds, whoſe food is of conſiderable firmneſs, as ſeeds.

Animals with *membranous* ſtomachs, ſuch as frogs, newts, ſnakes, fiſh, ruminating animals, carnivorous birds and beaſts, as the eagle, falcon, man, dog, cat, &c. This claſs is infiniteiy more numerous than the two former. It comprehends nearly all the quadrupeds, fiſh, reptiles, birds of prey, and the greater part of inſects. From Spallanzani's experiments, it appears, that carnivorous birds do not diſſolve vegetables, and throw up the indigeſtible part every twenty-four hours; that nature in theſe animals, whoſe digeſtion depends on the gaſtric juice alone, without any previous maſtication or trituration, has provided them with a much larger quantity of it than the other claſſes; that digeſtion is in proportion to the quantity of this fluid; that the gaſtric juice of the ruminating claſs has no effect in diſſolving plants unleſs they have been previouſly macerated, and ground by the teeth; that it's colour in ſheep is green, and yellow in cows; that owls digeſt fleſh and bones, but not grain; that their gaſtric juice evaporates ſooner than water; that, that of the eagle diſſolves bread and bone; it's colour is cineritious, and it digeſts animal and vegetable matters out of the body; that a wood pigeon may be brought by degrees to live on fleſh; that the owl and falcon do not digeſt bread; that the gaſtric juice of the dog diſſolves the enamel of the teeth; and that trituration is neceſſary in the ruminating order, and man, which is produced by the teeth, as in gallinaceous fowls by the gizzard; but in other animals, as in the frog, newt, ſerpents, and birds of prey, trituration does not contribute to digeſtion.

Hence, in every order of animals, the gaſtric juice is the principal cauſe of digeſtion, and it agrees in all in many properties, aud differs in others. In the frog, the newt, ſcaly fiſhes, and other cold animals, it produces digeſtion in a temperature nearly equal to that of the atmoſphere. In warm animals it is incapable of diſſolving the aliment in a degree ofheat lower than that of theſe animals. In warm animals the food is digeſted in a few hours, whereas in the oppoſite kind it requires ſeveral days, and even weeks, particularly in ſerpents; likewiſe, the gaſtric juice of the gallinaceous claſs can only diſſolve bodies of a ſoft and yielding texture, and previouſly triturated; whilſt in others, as ſerpents, the heron, birds of prey, and the dog, it decompoſes ſubſtances of great tenacity, as ligaments and tendons; and even of conſiderable hardneſs, as the moſt compact bone. Man belongs to this claſs, but his gaſtric juice ſeems to have no action on the hardeſt kind of bones. Some ſpecies, likewiſe, are incapable of digeſting vegetables, as birds of prey; but man, the dog, cat, crows, &c. diſſolve the individuals of both kingdoms alike, and are omnivorous, and in general their gaſtric juices produce theſe effects out of the body.

Hence, the diſſolving power of this fluid depends on the difference of the nouriſhment, and by ſome authors it has been ſaid to be the cauſe of hunger and of the difference in the choice of the particular aliment, by which power the carnivorous only enjoy fleſh; the graminivorous and ruminating, only vegetable aliments, and no fleſh; but man and the omnivorous, both vegetable and animal ſubſtances.

It is, however, aſſerted by Carradori as decided, that nocturnal birds of prey are capable of digeſting vegetables. It reſults from his experiments, that they alſo ſupport themſelves very well with this nouriſhment, in ſpite of their repugnance to it. If this be the caſe, the opinion is erroneous, that the gaſtric juice of theſe birds had only an affinity with animal ſubſtances; and what he has eſtabliſhed, viz. that carnivorous animals find a nutriment in the products of plants, was already rendered probable by the diſcovery of Fourcroy of the exiſtence of gluten, albumen, and gelatin in the vegetable tribes. Spallanzani, however, proves the inſufficiency of Carradori's experiments, as the owl died when confined to vegetable food.

The time requiſite for digeſtion is different in different animals. In many it does not exceed five or ſix hours, and in ſome it is much ſhorter.

From the numerous experiments of Goſſe of Geneva upon digeſtion, and the action which the gaſtric juice has upon different ſubſtances, great light has been afforded us upon this intereſting ſubject. Goſſe.

He informs us, that in about one hour and a half after the food is taken into the ſtomach, it is changed into a pultaceous maſs; the gaſtric juice, likewiſe, renders it fluid, without altering it's nature; and when digeſtion is properly carried on, there is no appearance of acidity or alcaleſcence; the food does not ferment; and the proceſs of digeſtion is not completed until the ſpace of between two and three hours has elapſed.

The chyme which ariſes from aliments taken either from the animal or vegetable kingdom is the ſame; they both are, by the gaſtric fluid, converted into the ſame ſubſtance, which is in cónſequence moſt probably of their both containing gelatin, &c. If, however, the digeſting ſolvent is not in ſufficient quantity, or is in a diſeaſed ſtate, the acetous fermentation will take place in vegetable, and the putrid in animal matter; hence milk, vegetable matter containing ſugar, wine, and even ſpirits will degenerate, when left to their ſpontaneous changes in the ſtomach, to a very ſtrong acid, and ſooner ſometimes than out of the body, perhaps from the heat, &c. All oily ſubſtances likewiſe become rancid, and fleſh meat putrid, producing acid and putrid eructations, which is never the caſe in a ſtate of healthy digeſtion; whilſt, in many animals the digeſtion is finiſhed before the acetous or putrid fermentation can begin.

Subſtances *inſoluble* or that were not digeſted in the uſual time in the ſtomach.

Animal ſubſtances.

1. Tendinous parts. 2. Bones. 3. Oily or fatty parts. 4. Indurated white of egg.

Vegetable ſubſtances.

1. Oily or emulſive ſeeds. 2. Expreſſed oils of different nuts and kernels. 3. Dried grapes, and the ſkins of fiſh. 4. Rind of farinaceous ſubſtances. 5. Pods of beans and peaſe. 6. Skins of ſtone fruits. 7. Huſks of fruits with grains or ſeeds. 8. Capſules of fruit with grains. 9. Ligneous ſtones of fruits. 10. It does not deſtroy the life of ſome ſeeds, hence bitterſweet, hemp, miſletoe, and other plants which ſometimes grow upon trees, are produced by the means of the excrements of birds, the kernels of the ſeeds being defended from the menſtruum by their exterior covering.

Subſtances *partly ſoluble*, or parts of which were digeſted.

Animal ſubſtances.

1. Pork dreſſed various ways. 2. Black puddings. 3. Fritters of eggs, fried eggs and bacon.

Vegetable ſubſtances.

1. Sallads of different kinds rendered more ſo when dreſſed. 2. White of cabbage, leſs ſoluble than red. 3. Beet, cardoons, onions, and leeks. 4. Roots of ſcurvy graſs, red and yellow carrots, ſuccory, are more inſoluble in the form of ſallad than any other way. 5. The pulp of fruit with ſeeds, when not fluid. 6. Warm bread and ſweet paſtry, from their producing acidity. 7. Freſh and dry figs. By frying all the ſubſtances in butter or oil they became ſtill leſs ſoluble. If they are not diſſolved in the ſtomach, they are, however, in the courſe of their paſſage through the inteſtines.

Subſtances *ſoluble* or eaſy of digeſtion, and which are reduced to a pulp in an hour, or an hour and half.

Animal ſubſtances.

1. Veal, lamb, and in general the fleſh of young animals, are ſooner diſſolved than that of old. 2. Freſh eggs, 3. Cows milk. 4. Perch boiled with a little ſalt and parſley. When fried or ſeaſoned with oil, wine, and white ſauce, it is not ſo ſoluble.

Vegetable ſubſtances.

1. Herbs, as ſpinach mixed with ſorrel, are leſs ſoluble. Celery. Tops of aſparagus, hops and the ornithogalus of the Pyrenees. 2. Bottom of artichokes. 3. Boiled pulp of fruits, ſeaſoned with ſugar. 4. Pulp or meal of farinaceous ſeeds. 5. Different ſorts of wheaten bread, without butter, the ſecond day after baking, the cruſt more ſo than the crumb. Salted bread of Geneva more ſo than that of Paris, without ſalt; brown bread in proportion as it contains more bran is leſs ſoluble. 6. Rapes, turnips, potatoes, parſnips, not too old. 7. Gum arabic,

but it's acid is ſoon felt. The Arabians uſe it as food.

Subſtances which *facilitated* the menſtrual power of the gaſtric juice, are ſea ſalt, ſpices, muſtard, ſcurvy graſs, horſe radiſh, radiſh, capers, wine, ſpirits in ſmall quantities, cheeſe, particularly when old, ſugar, various bitters.

Subſtances which *retarded* the gaſtric power are water, particularly hot and taken in large quantities. It occaſions the food to paſs into the inteſtines without being properly diſſolved. All acids, aſtringents, 24 grains of Peruvian bark, taken half an hour after dinner, ſtopped digeſtion. All unctuous ſubſtances, kermes, corroſive ſublimate. Goſſe likewiſe obſerved, that employment after a meal ſuſpended or retarded digeſtion, as well as leaning with the breaſt againſt a table, and that repoſe of mind, vertical poſition and gentle exercise facilitated it.

It likewiſe appears, that from the ſoluble power of this fluid, digeſtion goes on after death, but it is far leſs conſiderable than in the living animal; that in fiſhes it retains it's property of digeſting fleſh, but in an inferior degree to that of birds; and that in ſome animals heat is neceſſary to this power which acts independent of the vital power.

Hunter attributes to the action of the gaſtric juice, the eroſions found in ſtomachs of thoſe who have died ſuddenly, in which, ſometimes, the great curvature of that organ is entirely conſumed; he often found them on opening dead bodies, the edges of the wounds appearing like half digeſted food. Spallanzani, however, although he agrees with Hunter that digeſtion may take place after death, is of opinion contrary to that celebrated anatomiſt, that heat is neceſſary.

Dr. George Fordyce.

The opinion of Dr. George Fordyce appears to reſemble and ſupport thoſe of Spallanzani and Goſſe. According to this chemiſt, from the nature of the gaſtric juice and it's action upon different ſubſtances, when the ſtomach is in health, ſo as to ſecrete it in it's pure ſtate, the food is readily digeſted whilſt in weak ſtomachs; if the food be in too large a quantity, or does not readily enter into the digeſtive proceſs, or is a ſpecies which the ſtomach has not been accuſtomed to, the vegetable part will go into the acetous fermentation, and produce heartburn, vomiting, &c. and the animal into the putrid, whilſt the putrid matter, either by it's action upon the ſtomach, or it's introduction into the ſyſtem along with the chyle, he has known ſeveral times to produce a putrid and malignant fever.

He is of opinion that the ſubſtances taken into the ſtomach undergo ſuch a change as to become all the ſame ſubſtance, or as it has been called chyme, and that it is then rendered capable, but not before, of being converted into chyle. The properties, however, of chyme, are at preſent unknown. He thinks that this proceſs of the ſtomach is the moſt eſſential part of digeſtion.

Chyle.

The properties of the human chyle have not been inveſtigated, but according to Dr. Fordyce, as far as experiment has been carried, the chyle of quadrupeds, a claſs of animals in which man is to be ranked as far as he is not improved by culture, is ſo ſimilar as not to be diſtinguiſhed, not even in natural claſſes the moſt oppoſite to each other in their food, ſtructure, and habits of life. The chyle of a dog or of a wolf differs in nothing, as far as experiment has gone, from that of a ſheep or of an ox.

The chyle conſiſts of three parts, one part which is fluid and contained in the lacteals, but coagulates on extravaſation.

The ſecond part conſiſts of a fluid, which is coagulable by heat, and in all it's properties hitherto obſerved, it is conſonant to the ſerum of the blood.

The third part conſiſts of globules, which render the whole white and opake. Theſe globules have been ſuppoſed by many to be an expreſſed oil, but this has not been proved. Neither has it been perfectly demonſtrated that ſugar is contained in the chyle, although it has been made very probable. The difficulty of determining theſe points is, the ſmall quantity that can be collected, the largeſt animals not ſupplying more than one ounce or two, at the moſt. However, the part coagulating on extravaſation; the part agreeing with ſerum in it's qualities; the globular part, which in ſome animals, but not in quadrupeds, exiſts without giving whiteneſs to the chyle, alone, or along with ſugar, form the eſſential parts of the chyle.

A great many ſubſtances may enter the lacteals along with the chyle; even ſolids reduced to a fine powder. When indigo has been thrown into the inteſtine of a ſheep, Dr. Fordyce has ſeen the chyle rendered quite blue; yet indigo is not ſoluble in water, but is a ſolid reduced to a very fine powder. Muſk likewiſe gets into the chyle, giving it a ſtrong ſmell, and a great variety of other ſubſtances of various colours, various taſtes, and various ſmells; each of them giving colour, or taſte, or ſmell to the chyle. The lacteals, however, reject ſome ſubſtances in whatever manner they are applied; amongſt theſe are green vitriol and infuſion of galls, for the chyle gives no colour when either is given with food to the animal, or thrown into the inteſtine, and it is afterward tried by them as teſts of each other.

According to Dr. Fordyce, the chyle is not formed in the ſtomach. Milk is that food which comes neareſt to the chyle in it's external appearance, and as it is formed for the nouriſhment of young animals whoſe digeſtive organs are weak, and neceſſity for nouriſhment great, it is obvious, that chyle is ready prepared, or nearly ſo, in the veſſels of the mother, to ſave the powers of digeſtion in the infant. Yet, on this entering the ſtomach, there is a juice which coagulates it in a few minutes after, retards it in the ſtomach, and retains it there for a conſiderable length of time. The ſame is produced on the white of egg, and ſerum of the blood. This of itſelf would ſufficiently prove that there is a proceſs which it muſt go through previous to it's being formed into chyle. It further appears, that food diſſolved in water ſo as to form a ſolution not capable of being coagulated and not detained in the ſtomach, gives very little nouriſhment in proportion to the ſame quantity of the ſame food given in a ſolid form, or a coagulable one. Hence a decompoſition and recombination take place, but theſe do not appear to be the formation of chyle. Another circumſtance is, that if it was chyle, the abſorbents, which are numerous in the ſtomach, would take it up as faſt as it is produced, and would have the appearance of and actually be lacteals, and be perceived; but if a living animal be opened at any time during digeſtion, there is no appearance of any chyle abſorbed from the ſtomach, and hence there is none to be abſorbed. If we throw milk into a portion of the jejunum, it will be abſorbed by the lacteals, but if thrown into the ſtomach of the ſame animal, the milk will not be abſorbed by the lymphatics; hence it may be ſaid that the abſorbents of the ſtomach refuſe what thoſe of the jejunum readily take up; but the caſe is, that the milk is inſtantly coagulated in the ſtomach, and not in the jejunum, which coagulation will perfectly prevent it from being abſorbed; but all thoſe ſubſtances which are not changed by the coagulating juice of the ſtomach are equally taken up by the lymphatics in the ſtomach and lacteals.

It therefore appears that the uſe of the ſtomach is only to change the food into a new ſubſtance, the chyme, which is the only ſubſtance that can be converted into chyle. When this chyme is propelled into the duodenum, it is then converted into chyle, and not before; but the duodenum cannot have this action upon it, unleſs it has previouſly undergone the action of the ſtomach. There is nothing, therefore, in the whole doctrine of different ſpecies of food which can have any reſpect to any part of the body, excepting the ſtomach itſelf; for only thoſe parts of it that are converted into chyme will paſs into the duodenum and be converted into chyle; the other parts that have not undergone this change in the ſtomach will paſs through the duodenum unchanged, and be evacuated. So that according to Dr. Fordyce, it is perfectly immaterial what is the ſpecies of food, farinaceous matter, animal mucilage, apples, potatoes, wheat, muſhrooms or oyſters, beef, veal, chicken, ſalmon or gooſe. So long as it has undergone the proceſs of the ſtomach, and is converted into the matter formed by that proceſs, it gives equally good nouriſhment, and is equally innoxious, becauſe it becomes exactly the ſame. Sometimes a little whitiſh matter is ſeen about the pylorus, but this is not perfect chyle, for it is not ſeen in the abſorbents of the ſtomach, even although in the middle of digeſtion the pylorus be tied round by introducing a piece of tape, forming a ligature round it, and retaining the remaining food in the ſtomach. The matter, therefore, formed in the ſtomach, is converted into chyle in the duodenum, and continues to be converted in the jejunum.

As the coagulating juice of the ſtomach, as far as can be judged, does not enter into the matter or chyme formed in the ſtomach from the food, nor the other juices of the ſtomach, only in ſo far as they ſupply water; ſo neither do the juices of the duodenum, the bile, pancreatic juice, or fluids ſecreted in the glands of thed uodenum, or which may paſs through the exhalants, at all appear to enter into any part of the chyle. For, according to Dr. Fordyce, if the ductus communis choledochus be obſtructed by a ſtone, or if the body of an animal be opened when food has been thrown into the ſtomach, and the duct be tied up, by which the bile is prevented from getting into the duodenum; in either caſe the chyle is formed without any particle of bile being admitted; and the ſame may be ſaid of the pancreatic juice; ſo that chyle is ſolely the product of the matter formed by the digeſtive proceſs of the ſtomach. The chyle is always the ſame, but not always in the ſame proportion to the quantity of food. Scarcely any digeſtible matter is ever found in the duodenum, in the form it was thrown into the ſtomach; hence all of it ſeems to undergo ſome change or other.

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BILE.

THIS is a yellowiſh green fluid, which is ſeparated from the blood by means of the liver, a viſcus occupying a very large ſpace in the animal body. In man, and in the generality of quadrupeds, birds, &c. there is a reſervoir attached to this organ, which contains this fluid in more or leſs quantity; in man, it has been computed at an ounce on an average; but in the elephant, ſtag, and in all inſects and worms, this reſervoir is wanting. Bile.

The bile in man, and in quadrupeds, &c. is not only collected in the gall bladder, from whence it is conveyed by the cyſtic duct, but another portion of bile is brought directly from the liver itſelf, and flowing into the hepatic duct, joins the cyſtic by the name of the ductus choledochus communis, and enters the duodenum; hence the bile may be divided into the hepatic and cyſtic.

Two kinds.

1. The *hepatic bile* has not as yet undergone any chemical inveſtigation; it is, however, ſaid to be milder in it's taſte, leſs highly coloured, and thinner in conſiſtence than the cyſtic.

Cyſtic bile.

It's properties.

2. The *cyſtic bile*, when pure and in a healthy ſtate, is of a green colour, inclining to a yellow; this, however, appears to depend on the quantity of aqueous fluid it contains; for when diluted, this yellow tinge is very conſpicuous; and when in a more concentrated ſtate, it is of a deep green. In the greater number of quadrupeds, and in man, it is of a yellowiſh green, but in birds, oviparous animals and fiſh, it is conſtantly green; it is likewiſe ſaid to be much darker in carnivorous than in grami-

nivorous animals. In diſeaſes it is of all ſhades, from a pallid hue to a direct black; thus in cachexy and dropſy it is very pale; whilſt in melancholia, yellow fever, and plague, it approaches more or leſs to a black. There are inſtances of it's being affected by aliments, and of it's being tinged by the uſe of different vegetables.

It's ſavour is very bitter, accompanied with a certain degree of pungency; if, however, aloes be mixed with it, the production is ſaid to be a ſweetiſh taſte. This natural ſavour is ſtronger in the bile of carnivorous than of herbivorous animals, and in oviparous quadrupeds it is ſaid to be exceedingly pungent, but not very bitter; and the ſame is the caſe with that of fiſh; whilſt examples are recorded of this fluid becoming ſomewhat acetous to the taſte.

In conſiſtence, it is viſcous and tenacious, reſembling a ſirup or oil, and when agitated in a phial it foams like ſoap water. On it's firſt flowing into the gall bladder, it is more aqueous than after it has reſided there ſome time, and at times it is found in part coagulated. This tenacity in the bile Dr. Saunders ſeems inclined to explain, from it's being a compound fluid, conſiſting in part of genuine bile, with a portion of the mucus ſecreted by the gall bladder.

The conſiſtence, taſte, and colour, however, are properties of this fluid which appear to depend on the ſame cauſe, for the more aqueous it is, the more light coloured and leſs bitter; on the contrary, if it's viſcidity be increaſed, it's ſavour and colour are of conſequence increaſed in ſtrength; and it is found to be more viſcid, more bitter, and deeper coloured in the gall bladder than as it flows from the liver, from the aqueous parts being taken up by the abſorbents. In adult animals in health, it is likewiſe more viſcid, deeper coloured, and more bitter than in younger ones, whilſt in the fœtus, it is ſaid to be ſweetiſh, very aqueous and of a reddiſh hue. It is likewiſe more viſcous in man than in quadrupeds.

In diſeaſes theſe differences are more evident.

It's odour is diſguſting and nauſeous, but in ſome animals, when freſh, it is ſaid to poſſeſs an agreeable ſmell ſimilar to that of muſk; whilſt in others, this muſky ſmell may be obtained by evaporation, or they obtain it ſpontaneouſly by putrefaction.

It is ſpecifically heavier than diſtilled water, but it differs greatly in this reſpect; according to Muſchenbrœck, the proportion is as 1,0246 to 1,0000.

Diluted with a little water, it changes the ſirup of violets green.

It is perfectly ſoluble in water, and affords a clear ſolution of a more or leſs yellow colour, according to the quantity of menſtruum.

All the acids on being added to this fluid, decompoſe it in the manner of ſoaps and alſo produce a coagulation of the albumen. If the mixture be filtrated, and the liquor evaporated, a neutral ſalt is obtained, compoſed of the acid employed and ſoda. This beautiful experiment is due to Cadet, and ſhows the preſence of ſoda in the bile. According to Fourcroy, the matter left on the filter is thick and viſcous, and compoſed of two different ſubſtances; the one is the coagulated albumen, the other a bitter and very inflammable matter, varying in colour and conſiſtence according to the degree of concentration of the acid employed to ſeparate it.

The preſence of ſoda in bile.

Albumen and reſin.

Theſe acids affect the colour of the bile; thus, by the ſulphuric, a deep green is produced; the nitric, when a little concentrated, gives it a brilliant yellow, and the muriatic a very beautiful clear green. Theſe colours, however, vary according to the ſtate of the bile and the acids. If bile be previouſly diluted with water before the addition of the acids, we are informed by Hildebrandt

Acids affect it's colour.

that the part which is not coagulated remains diſſolved in the water. The precipitate above mentioned has been looked upon, particularly by Van Bochante, a chemiſt of Bruſſels, (in a diſſertation on the colouring matter of the bile,) as a ſubſtance analogous to the reſins. On being placed upon red hot coals, it ſwells, melts, and inflames; it is totally diſſolved by alcohol, and precipitated again by water, like the reſinous juices. According to Fourcroy, the action of the acids ſhows, that the bile is a real ſoap formed of an oil analogous to the reſins; united to ſoda, they likewiſe announce the preſence of a certain quantity of albuminous matter in this animal liquor, which is the cauſe of it's being coagulated by them, as well as by heat and alcohol, as will ſoon appear. It is likewiſe this part of the bile that undergoes the putrid fermentation.

The action of acids proves the bile to be a real ſoap.

The colour deſtroyed by oxygenated muriatic acid.

According to the ſame chemiſt, the oxygenated muriatic acid deſtroys the colour of bile, and coagulates it's albumen, which is precipitated in the ſtate of white flocks; the biliary ſoap remains in ſolution, which in appearance is nothing but pure water, having loſt it's colour and odour, and only preſerving all it's bitterneſs. If more of the acid has been added than is ſufficient to coagulate the albumen, the exceſs acts by degrees upon the oil of the ſoap, and returning again to ordinary muriatic acid, decompoſes a part of the ſoap and ſeparates it's oil in a concrete form, and of a white colour. Since it appears, that it is only by furniſhing the albumen with oxygen, that the oxygenated muriatic acid coagulates the bile; this chemiſt thinks it probable, that the portion of this acid returned to it's ſimple ſtate decompoſes a certain quantity of the biliary ſoap, and conſequently, the albumen is always mixed with a little of the reſin or the concrete oil of the bile.

If a ſimple acid, as the ſulphuric or muriatic, &c. be added to the bile, after it is become colourleſs by the oxygenated muriatic acid, a white concrete precipitate is immediately formed of the conſiſtence of fat. This precipitate, which is the oil of the bile ſomewhat changed by the oxygen of the muriatic acid, perfectly mixes with water, and is even diſſolved by the aid of heat. This property is the more ſingular, ſince the ſoda which renders it ſoluble is no longer preſent; having united to the acid uſed in the decompoſition of the bile.

A white concrete oil found on adding a a ſimple acid to the colourleſs ſolution.

This *white concrete oil* is ſoluble in the cold, in alcohol; and if the ſolution be accelerated by heat, a certain quantity of æther is formed, which appears to ariſe from the oxygen contained in the oil uniting with the alcohol, and changing the proportion of it's principles. The alcoholic ſolution expoſed to the air loſes it's alcohol by degrees; but it is with great difficulty that it becomes ſolid. If, when it is about the conſiſtence of a ſirup, it be mixed with water, it unites perfectly with it, which ſeems to announce, that the biliary ſoap has not been decompoſed; but when an acid is added to this ſolution, a precipitation is immediately the conſequence. Another experiment not leſs ſingular is, that if a freſh quantity of alcohol be put to the ſolution of the oil of the bile, thus inſpiſſated by the air and water, and afterwards added, an abundant precipitate takes place.

Properties of the white oil.

It appears, that the ſame phenomenon of the ſolubility in water of this bilious oily matter, which was pretended to be a reſin, had been previouſly obſerved before in the laboratory of this chemiſt; but it would ſeem, that this pretended reſin, which is precipitated by an acid, is in part ſoluble in water, and only takes an apparent character of inſolubility in this fluid, from the preſence of an acid.

It was conjectured, that this white concrete oil had ſome analogy to the white and cryſtalline matter of the

Differs from the cryſtalline matter

of biliary calculi.

human biliary calculi; but it was ſoon evident that it differs from it in ſeveral properties.

1ſt. It is more ſoluble in alcohol, and is not precipitated in ſmall lamellæ.

2d. It is ſoluble in water.

3d. It is of much ſofter conſiſtence and more fuſible, being nearly equal to the fuſibility of fat (at 32° or 33°), whilſt the cryſtalline matter of the human biliary calculi only melts at a heat above 90°, and remains ſolid at a few degrees above boiling water.

Action of ſalts upon bile.

The neutral alkaline ſalts mixed with bile prevent its putrefaction; the ammoniacal ſalts are decompoſed by it; the earthy neutral ſalts are decompoſed, and precipitate it.

Metallic ſalts decompoſe it, and are decompoſed at the ſame time by it; the ſoda of the bile unites to the acid of the ſolution, and the coloured oil of bile is precipitated in union with the metallic oxyd.

Unites with oils.

Bile unites readily with oils, and like ſoaps takes out any greaſy ſpots from cloth; hence the bile of the ox is uſed in cleanſing ſtuffs.

Bile a real animal ſoap.

The bile, or biliary ſoap as it may be properly called, is ſoluble in alcohol, which ſeparates it's albumen in a coagulated ſtate. This tincture of bile is not decompoſed by water, which ſhows the ſubſtance to be a real animal ſoap, equally ſoluble in water and in alcohol.

It is likewiſe eaſily diſſolved by æther.

Putrefies ſooner than blood.

Dr. Saunders, in order to try whether the bile had a greater power of reſiſting putrefaction than the blood, put equal quantities of blood and bile of the ſame ox into different veſſels of the ſame ſize, and expoſed them to the ſame degree of heat, and found that on the third day the blood began to ſhow ſigns of putrefaction, whilſt the bile remained in it's natural ſtate; on the fourth day the bile had a pungent odour by no means ungrateful, whilſt the blood was extremely putrid. On the 6th day the bile became putrid, and had a very offenſive ſmell. The progreſs of putrefaction in bile is, according to obſervation, as follows:

Action of heat upon bile.

Expoſed to the air, at a warm temperature of from 15° to 25°, a change very ſoon takes place; it's aroma becomes at firſt nauſeating; it's colour changes; whitiſh mucilaginous flocks are precipitated; it loſes it's viſcoſity, and ſoon becomes fœtid and ſtrong to the organs of ſmell. When the putrefactive proceſs is far advanced, it's odour becomes mild and ſomewhat reſembling ambergris. It has been obſerved by Vauquelin, that after inſpiſſating ſomewhat bile in the baln. mar. it keeps ſeveral months without change, as is the caſe with vinegar when boiled. He found that the bile of the ox, which exhaled a fœtid odour, was of a dirty brown colour, and turbid; became on being heated of a beautiful green; loſt it's odour whilſt ſome albuminous concrete flocks were ſeparated, and that it is no longer ſo ſubject to change as when it is in it's natural ſtate. When ſubmitted to diſtillation, there ariſes a phlegm which ſhews no traces either of an acid or an alkali; after a certain time it becomes putrid. This phlegm has often preſented to Fourcroy a well marked, mild, aromatic odour, very analogous to that of ambergris or muſk. The obtaining this aroma particularly ſucceeds, if the bile be diſtilled after it has been kept a few days, and is a little changed. The ſame is the caſe with bile, after having being ſomewhat inſpiſſated, and kept a long time.

It's muſky odour.

When bile has been inſpiſſated, by a ſufficient expoſure to heat, to a more or leſs dry extract, it is of a deep green or brown colour, very tenacious, and of a pitchy conſiſtency; it deliqueſces, and is nearly wholly ſoluble in water. On being diſtilled the inſpiſſated bile affords a yellowiſh alkaline phlegm, an empyreumatic oil, a

Products of inſpiſſated bile on diſtillation.

large quantity of carbonet of ammonia, an elaſtic fluid mixed with carbonic acid, carbonated by hydrogenous and azot gases. The remaining coal is found in large quantity, and, according to Maçquer, very ſaline; it is leſs difficult of incineration than that of moſt other animal ſubſtances. According to Cadet, who preſented to the academy, in 1767, an excellent memoir on the analyſis of the bile, this coal contains carbonat of ſoda; an animal earth, *i. e.* phoſphat of lime, and a ſmall quantity of oxyd of iron. If the bile be diſtilled on the open fire, great caution is neceſſary from it's ſwelling conſiderably. When heated to 60° it coagulates, and becomes a flocky, thready maſs, which ariſes from it's albumen. Fourcroy has likewiſe obſerved in the products of the bile, after diſtillation, in the retort, and rectification, a ſmall portion of pruſſic acid, partly free and in part combined with ammonia.

When bile has loſt it's oil by expoſure to a ſtrong heat, it's carbon is difficult to incinerate; for we are informed by Fourcroy, that whilſt it is undergoing a red heat, the ſoda ſo eaſily volatilizes, that the aſhes being ſtill blackiſh, no longer contain any alkali, and ſhow no traces of it in water. Incineration appears, therefore, a defective proceſs to arrive at the fixed parts of bile, and more eſpecially to determine their proportion.

Component parts of bile.

On collecting the component parts of the bile, it is found to contain a large portion of water; a peculiar concreſcible oil united with ſoda, forming a ſaponaceous ſubſtance; and an albuminous mucilage which is coagulable. Several other ſubſtances, beſides it's aroma and colouring matter, are ſaid to contribute to it's formation. Thus, Cadet, independent of the phoſphat of lime, thinks he found a ſalt in the coal of the bile, of the nature of ſugar of milk, the exiſtence of which Van Bochante has ſince confirmed; but Fourcroy is of opinion, that this pretended ſaline matter is rather to be looked upon as analogous to the oily, leafy, brilliant and cryſtalline ſubſtance that Poulleter found in the human biliary calculus, and Hildebrandt is of opinion, that the ſubſtance which communicates a bitter ſavour to the organs of taſte forms an eſſential part of it; ſince it appears from the experiments of Leonhardi and Richter, that bile, even when reduced to a coal, ſtill retained it's bitterneſs. Common ſalt and iron have likewiſe been ſaid to be found in it; but according to other chemiſts, theſe are only accidental.

Opinion of Hildebrandt on it's bitter taſte.

The laſt chemiſt who has paid any attention to the component parts of bile is Dr. Saunders. This phyſician, from various experiments, concludes, that it conſiſts, 1. Of water impregnated with the odorous principle. 2. A mucilaginous ſubſtance, reſembling the *albumen*. 3. A reſinous ſubſtance containing the colouring principle and bitter taſte, and 4. The mild mineral alkali. With reſpect to their combinations he is of opinion, that the ſaponaceous matter conſiſts of the bitter reſin in union with the alkali; that this admits of a ready union with a mucilage, and with this again the aqueous matter.

It's component parts according to Saunders.

Homberg, Bourgelat, Cartheuſar, and Ramſay, have made a few experiments on it with acids and a few ſaline bodies, but they have contributed nothing towards the diſcovery of it's component parts; and, perhaps, little was done reſpecting it's analyſis, till Cadet, by a courſe of well directed experiments, threw more light upon it than all his predeceſſors had done before him. He is ſaid to be the firſt who actually diſcovered the preſence of ſoda in it, although Roeder had ſhown the exiſtence of it much about the ſame time. This fluid had, indeed, been long made uſe of in the cleanſing of greaſy and oily ſpots from cloth, from it's having been found to poſſeſs ſaponaceous properties; but independent of this, ſeveral phyſicians, ſuch as Burggrave, Hartmann, Baglivi, and Verheyen, had made ſome few experiments upon it, by which the preſence of an alkali had been detected. It was likewiſe known, that by the addition of acids the gall became turbid, and that on mixing them with a ſolution of ſoap, they equally brought about the ſolution of an oily matter. At length the work of Gardani appeared, from whoſe experiments, made with great care and diligence, it was proved, that this fluid had the power of precipitating ſalts with a metallic baſis. All theſe facts ſufficiently ſhow the preſence of an alkaline ſalt, and agree very well reſpecting it's ſaponaceous property; but there remained to diſcover the nature of the Cadet. alkali, which was effected by Cadet, in an excellent treatiſe on the bile, read before the Academy of Sciences, and printed in the year 1767. He found that on treating bile with the muriatic acid, he obtained by cryſtallization common ſalt; with the nitrous acid, it gave the nitrat of ſoda; and with vinegar, a cryſtallized neutral ſalt compoſed of ſoda and the acid employed; which experiments clearly convinced him, that the gall contained an alkali, and that this alkali was the ſame as that which aſſiſted in the compoſition of common ſalt or ſoda; and having afterward found the ſame alkali in the aſhes after incineration, every doubt was cleared up of it's nature.

Cadet likewiſe found, that the mineral acids at firſt produced a coagulation of the bile; but afterward diſſolved and brought it to a ſtate of greater fluidity; he confirmed the preſence of calcareous earth in it by the formation of ſelenite on the addition of the vitriolic acid; ſhowed, that the aqueous part of the bile contained a ſalt reſembling the ſugar of milk, and that it likewiſe poſſeſſed amongſt it's component parts an animal fat, common ſalt, and a little iron.

Rœderer. Rœderer, who, as before obſerved, had been engaged in making experiments much about the ſame time as Cadet, or a little before, in 1767, coincided in great meaſure in the reſults. He found, that on mixing the three mineral acids with gall, he obtained from the fluid which covered the gummy reſinous precipitate that fell down cryſtals of Glauber's ſalt, of cubic nitre, and of common ſalt; a clear proof of the preſence of mineral alkali in this animal fluid. He thought, however, that this alkali appeared to be in part ſaturated with muriatic acid; for the coal of the bile, beſides ſome oblong cryſtals that efferveſced in the air, (but which ought not to have been taken for Glauber's ſalt without further proof, being certainly mineral alkali,) afforded him likewiſe cubic cryſtals that decrepitated in the fire. He, likewiſe, as well as Cadet, found the preſence of calcareous earth in bile from the production of ſelenite with vitriolic acid; but the exiſtence of iron had eſcaped his notice; he however thought he had found an acid in it, and that it had the power of coagulating milk; but Cadet proved the contrary, and conjectured that the acid, if it exiſted, might have ariſen from the gelatinous part of the bile.

Different opinions of it's ſaponaceous nature.

With reſpect to the ſaponaceous nature of this fluid, opinions have been different, ſome contending for the affirmative, others aſſerting the negative. The idea of it's being a ſoap originated from it's cleanſing property; but this is only one of the properties which a real ſoap poſſeſſes; hence, other experiments were neceſſary to arrive at the truth. Geſner was not able to diſſolve ſuet either with the aqueous ſolution of dried gall, which had been kept a year, or with freſh ox bile. Schroeder was likewiſe unable to bring about a ſolution either of the reſinous or oily ſubſtances in bile. Rœderer found, by experiment, that the fat oils united better with bile than with ſoap, but that their union with the laſt was more durable; that bile did not entirely refuſe to unite with ethereal oils; but that, old oil of turpentine excepted, it was not able to bring them to any ſolubility in water, and that it ſhowed not the leaſt ſolvent power upon the reſins. It was in conſequence of theſe experiments and others, which ſeveral chemiſts had given to the world, to prove that bile cannot be mixed either with ethereal or fat oils or butter, or render thoſe bodies ſoluble in water, that ſome chemiſts affirmed, more particularly Schroeder, Goldwitz, and Jacquin, that bile ought not to be conſidered as a ſoap; and the laſt has concluded, that if it be employed with ſucceſs for removing ſpots out of cloth, the reaſon is, that the bile has a greater affinity with the cloth than the fat oils, which are conſequently diſengaged and iſſue in drops. Leonhardi is, however, of opinion, that as it appears from decompoſition, that bile contains volatile as well as fixed alkali, with oily parts in it's compoſition, and that ſince it can unite fat oils with water, although the union is not ſo laſting as when ſoap is uſed, the ſaponaceous character cannot be entirely denied it. Robert had affirmed, in a diſſertation, entitled, An bilis ſapo acido-alcalinus, Paris, 1759, that there was a double ſoap in bile, an alkaline and an acid one; but he could not ſupport his aſſertion by any chemical experiment. Macquer concluded, that it poſſeſſes a peculiar property approaching to a real ſoap, conſiſting of fixed mineral alkali, and ſuch a quantity of oil as is neceſſary to give riſe to ſuch a ſaponaceous mixture as bile is allowed to have. At laſt, Fourcroy, as before mentioned, added greater light by his experiments on this ſubject, and proved, that it is an oily and ſaponaceous ſubſtance, compoſed of an oil nearly approaching to the ſtate of ſpermaceti, together with a quantity of liquid albumen.

With reſpect to the component parts of bile, Durande and Willink had atteſted the preſence of iron in it; but neither Maclurg, by means of galls, nor the experiments of Leonhardi were able to detect it; and the latter is of opinion, that it is only accidentally met with in this fluid. Goldwitz endeavoured to prove that oil, air, alkali, and iron were not contained in it; that the lacto-saccharine ſpecies of ſalt was only accidentally preſent in ox gall, and only then in the ſpring; and that it's component parts, beſides coagulable lymph, conſiſt of a liquid peculiar to it formed of water, phlogiſton, and a very ſmall quantity of earth. That bile contained no alkali this chemiſt concluded, becauſe it did not efferveſce with acids, which every alkali ought to do; and Stræhl, who publiſhed a book at Gottingen, de Bilis Natura, in 1787, ſupported Goldwitz in his opinion. On the contrary, Richter undertook the defence of the exiſtence of an alkali in bile. He found, that the experiments of Cadet and Rœderer were entitled to every claim of veracity; for each of the mineral acids, after being added to this fluid, formed a coagulated and more or leſs green or yellow coloured precipitate; and the fluid above it, on evaporation, afforded a neutral ſalt, of the ſame nature as that which the mineral alkali forms with the ſame acids. With vinegar an arboreſcent cryſtallization aroſe, which, however, he would not affirm to be acetated ſoda; he likewiſe obtained common ſalt by means of diſſolving the extract in alcohol. Having incinerated the coal from bile, and made a ley of it, he got by the addition of vitriolic acid Glauber's ſalt by evaporation, whilſt a portion to which no acid had been added afforded mineral alkali; he alſo, on incineration, obſerved a ſmell of garlic, which called to mind the preſence of Prouſt's ſalt, or the mineral alkali united to phoſphoric acid. Leonhardi is of opinion, that the alkali certainly exiſts in bile, either in a free ſtate or imperfectly ſaturated

Opinions of it's conſtituent parts.

with the phoſphoric acid; for in his experiment with the freſh bile of the pig, which, according to Delius, approaches the neareſt to the human, litmus paper became much darker, and turmeric paper of a browniſh red. With reſpect to common ſalt, it appears from the ſupplement to Richter's Memoir, by Delius, that it's preſence was detected in human bile by the microſcope, in the form of cubic cryſtals, as well as the preſence of an ammoniacal ſalt of a cruciform ſhape. Leonhardi thinks, that the volatile alkali obtained in the diſtillation of bile is certainly united with an acid. Richter obtained an oil from bile, but in very ſmall quantity, by diſtillation; and Prieſtley ſhowed the preſence of phlogiſton on treating the extract with nitrous acid, and producing nitrous gas; whilſt other animal ſubſtances treated in the ſame manner only afforded phlogiſticated air. Gren believed there was a reſin in it from the ſolubility of a part of the extract in alcohol, and that this bitter reſinous part was united with water, lymph, alkali, and gelatin, the remaining component parts. The bitter part appears to Leonhardi to be fixed, ſince the coal, both in his experiments and in thoſe of Richter, was found to have a bitter ſavour. He thinks it not improbable, but that this bitter matter may conſiſt of the ſaccharine acid, deprived in part of it's fixed air, and united in different proportions with oily or inflammable parts; which acid, according to Berthollet, is found in animal as well as in vegetable bodies. Flour ſpoiled by moiſture, rotten apples, and rancid fat oils, all have a bitter taſte. Theſe contain acid of ſugar and loſe fixed air. Bile appears to this chemiſt, by it's bitterneſs, to oppoſe and prevent the extrication of fixed air, ſo that the fat parts of the chyle do not become rancid, the gelatinous parts putrid, nor the mucilaginous parts, capable of the vinous fermentation, ſour; beſides, according to the experiment of Milman, bile impregnated with fixed air is longer in becoming putrid than without it. From this ſhort and general hiſtory of the experiments upon bile, it appears, that it is to Cadet and Rœderer we are indebted for the diſcovery of the preſence of ſoda in that fluid, which is acknowledged to exiſt in a diſengaged ſtate; and to Fourcroy for the knowledge of it's other component parts.

USE OF THE BILE.

Various opinions on the uſe of the bile.

The grand object of chemiſtry in the analyſis of animal ſubſtances is to aſſiſt the phyſiologiſt in diſcovering the nature and utility of the matter ſubjected to his inveſtigation, and to endeavour not only to account for it's formation, but to lay before the phyſician the means which may be employed to protect or abſolve it from the action of diſeaſe. The variety of opinions which have been given on the uſe of the bile, is a great proof of the obſcurity in which this function is enveloped; and ſhould the concluſion, that has been drawn from the analyſis of this fluid, not be rendered perfectly ſatisfactory, it is at leaſt to be hoped, that it may ſtimulate the ſcientific chemiſt and phyſiologiſt to redouble his efforts on ſo curious and intereſting a ſubject of inquiry.

The conſtancy of the bile in every animal, even in inſects and worms; the ſize of the viſcus that prepares it, and the deſtructive and grievous conſequences ariſing from it's diſeaſes, are very convincing proofs of the important part it acts in the animal economy. The great purpoſe to which this fluid is deſtined, according to phyſiologiſts, and more particularly thoſe of the preſent time, is that of aſſiſting the proceſs of digeſtion; and Fourcroy, to whom we are indebted for ſo many experiments on the ſubject, is of opinion, that to promote and facilitate the digeſtive proceſs, is one of it's uſes. He thinks, that it's ſoapy quality renders it capable of uniting the oily parts of the alimentary matter to water; that it's bitter ſavour indicates it's being a ſtimulus to the inteſtines; and that it favours their action upon the aliments. It appears to him, that it is decompoſed in the duodenum by the acids which exiſt, or which are almoſt always forming in the organs of digeſtion; and that at leaſt it is certain it is very much changed, particularly in it's colour, when it becomes a portion of the excrements to which it communicates the yellow hue.

Galen. Some of the ancients as well as moderns, looked upon it in a very different light. Galen and Paracelſus were of opinion, that it was nothing but an excrement; Roux, that it's principal office was to evacuate the colouring part of the blood from the body; and Liſter affirms that it is of no uſe whatever. Liſter.

With reſpect to it's uſe in digeſtion, if the formation of chyle be the object, Dr. G. Fordyce has proved, that if the ductus communis choledochus be obſtructed by a ſtone, or tied up artificially in animals, it does not prevent the formation of chyle; hence the bile can be of no uſe in that proceſs.

Fourcroy. Fourcroy ſeems to think, that it is deſtined for another purpoſe beſides digeſtion. He is of opinion, that the blood, as it circulates through the meſenteric, ſplenetic, and hepatic arteries, and afterward into the diviſions of the vena portarum, undergoes great changes in it's nature; whether, as phyſiologiſts ſay, it diſſolves and takes with it ſome of the fat of the inferior abdominal region, which is ſcarcely poſſible; or rather, on traverſing theſe different regions very gradually, the carbon it contains unites with the oxygen, which, as it were, has only been interpoſed between the molecules of it's component parts during reſpiration in paſſing through the lungs; and conſequently being a long time in regaining that viſcus, it aſſumes a fat character from the ſuperabundance of hydrogen which it communicates to the organs it nouriſhes and ſupports. If this be the effect in man and in quadrupeds, whoſe reſpiration is ſo perfect, in the veſſels through which the blood circulates with rapidity, it ought to be infinitely more marked in thoſe animals who are able to live a long time in the mud or moſt infectious filth without breathing, and when reſpiration does take place, is only in a very limited and imperfect manner, from the ſmallneſs of their reſpiratory organs, and the conſequent admiſſion of a very ſmall quantity of air; which air cannot be intimately united with the humours for a long time after it's reception, from the ſlowneſs with which they circulate. Hence theſe amphibious animals are more or leſs ſoft and cartilaginous, pale, and even colourleſs throughout their compoſition; have very little ſenſibility, and are without agility. This chemiſt has drawn theſe concluſions from the component parts of the bile, from finding traces of oil ſometimes on tearing or cutting the human liver, and that of quadrupeds; from the liver of the ray containing more than half it's weight of oil perfectly formed; from certain parts of the lower belly in diſeaſes of the liver taking a fat character, and becoming white or rather gray like the liver of the ray; from the livers of flying animals, particularly of birds expoſed to a high temperature, and fed on milk, taking the ſame character; and from the ſize of this viſcus in amphibious animals when compared to others, and the liquidity and oilineſs of their brain, which may be attributed to a very limited reſpiration.

Dr. Saunders looks upon the particular office of the bile to be a ſtimulus to the inteſtines, keeping up their Saunders.

energy and periſtaltic motion. It is alſo ſaid, that by virtue of it's alkaline nature it corrects acidity, reſiſts fermentation, and in conſequence of it's bitter quality, retards the putrefactive proceſs.

Is not the bile merely an excrement?

If I may be permitted to hazard a conjecture upon the uſe of the bile, and the viſcus that ſecretes it, it would appear, as Fourcroy has well obſerved, that the liver has a great connection with the lungs, not only from the facts already mentioned, but from the large ſize of this viſcus in the fœtus which has not yet reſpired; and that whatever action the bile may have upon the food, or on the inteſtines in digeſtion, there is reaſon to believe that the liver deprives the blood which paſſes through it of ſome of it's noxious parts, performing an excrementitious operation in the abdomen, whilſt the lungs are acting to the ſame end in the thorax. This appears probable, not only from the large ſize of the liver in thoſe animals of limited reſpiration, but even the extent of this viſcus in man and quadrupeds, which is by far the moſt voluminous gland in the body, indicates, that it's action muſt be of greater extent than that of furniſhing a mere ſecretion. All the glands form their ſecretions from the blood in it's moſt perfect ſtate, or as it circulates through the arteries; whilſt on the contrary, the liver makes uſe of the impure venous blood, ſupplied by the vena porta; which blood has been ſaid by ſome, although denied by others, to be in a ſtate of greater fluidity, and to have a putreſcent tendency, ſo as ſcarcely or not at all to be coagulated; or in other words, poſſeſſing a ſuperabundance of ſoda, which preſerves it's fluidity, and of carbon and hydrogen, which give it a dark colour. If this be the caſe, it is probable, that as this blood circulates through the liver, this viſcus deprives it of the hydrogen and carbon, which, united to a little oxygen, form an oily matter, and meeting with the ſoda, a ſaponaceous ſubſtance is produced, which forms the principal character of the bile. Hence ariſes the neceſſity of this fluid being made with conſtancy and regularity, for the integrity of all the functions; and the reaſon of it's exiſting in all animals, and of it's being as neceſſary as the evacuation of the lungs during reſpiration. In thoſe animals whoſe reſpiratory organs are very ſmall in compariſon to their body, and where the carbon and hydrogen muſt be in large quantity in their blood from the want of proper evacuation, the liver is remarkably capacious and great in proportion, by which means theſe ſubſtances are evacuated in the form of bile, the act of reſpiration being inconvenient to their mode of life. It is by ſuch means that theſe two viſcera aſſiſt each other, (vide animal oils). To this opinion of it's being an excrementitious matter, may be added ſeveral other properties of a like nature, viz. it's nauſeous and diſguſting ſmell and taſte.

It appears, from the experiments of Fourcroy, that the oily part of the bile is nearly in the ſtate of ſpermaceti, preſerving it's fluidity during a ſtate of health. When, however, this matter is too abundant to remain in ſolution in the bile, it becomes cryſtallized, forming the calculi of the gall bladder, or gall ſtones, which, on analyſis, evidently appear to owe their formation to this oily concreſcible matter; and this matter being contained either in the pores or parenchymatous ſubſtance of the liver, often proves the ſource of ſeveral of it's diſeaſes.

To conclude, whatever may be the functions of the liver, and the uſe of the bile, many experiments are neceſſary before any real proof can be had that is perfectly ſatisfactory; and as much may be brought againſt every opinion which authors have yet given, it follows that the liver fulfills an operation, the whole of which ſcience has not embraced.

Haller's Element. Phyſiol.—Encyclop. méthod. tom. 2. chimie. p. 564.—Cadet, Experiences chimiques ſur la bile des hommes & des animaux, in the Mém. de l'Acad. de Paris, 1764; alſo his Nouvelles Récherches pour ſervir à déterminer la nature de la bile, ibid. 1769.—Jo. Mich. Roederer, Experimenta circa bilis naturam. Argent. 1767.—Schrœder, Experimenta ad veriorem cyſticæ bilis indolem de clar. capt. ſect. 1. Gotting. 1764.—Sebaſtian Goldwitz neue Verſuche zu einer wahren phyſiologie der Galle. Bamberg, 1785.—Guil. Mich. Richteri experimenta & cogitata circa bilis naturam, imprimis ejus principium ſalinum. Acc. Henric. Frid. Delii de bile humana Epiſtola. Erlang. 1788.—Jacquin's Elements.—Macquers Wœrterbuch von Leonhardi, article Gall.—A Treatiſe on the Structure, Œconomy, and Diſeaſes of the Liver, &c. by Wm. Saunders, M. D. F. R. S. &c. London. 1795.—2d edit.

SALIVA.

THIS, when freſh, and in a healthy ſtate, is a tranſparent colourleſs liquor, without aroma or ſavour, and is ſecreted into the mouth of an animal to aſſiſt in the maſtication of it's food.

It's proper-ties.

It's ſpecific gravity, according to Haller, is to water as 1960 to 1875.

In carnivorous animals, it is ſaid to be ſomewhat acid, and manifeſtly ſaline; and in the human ſubject, in diſeaſe, from having no ſavour becomes bitter, ſharp, ſweet, ſour, putrid, or ſaline, and ſometimes it is ſaid to partake of ſeveral of theſe ſavours at the ſame time.

In conſiſtence, it is ſomewhat leſs fluid than water, but more ſo than mucus; it does not freeze ſo ſoon as water, and when mixed with air, is converted into froth.

It is imperfectly ſoluble in water.

It mixes imperfectly with oils to a milky fluid.

It has no action on the tincture of litmus or ſyrup of violets.

Alcohol in ſome meaſure coagulates it.

Acids in ſmall quantity produce a flocky appearance, in large quantity they diſſolve it.

According to Plenck, cauſtic alkalis and lime extricate ammonia from it.

From Pringle's experiments, it poſſeſſes a ſeptic quality.

In a warm atmoſphere it ſoon runs into the putrid fermentation.

It appears to have a ſlight action on ſome of the metals, as iron and copper.

Acts upon iron and copper.

It's component parts.

It's component parts appear to be four-fifths of water, albumen, according to Pleuck ammonia, and an animal earth, which, according to Weber, contains muriat of ſoda, to which he has added calcareous earth.

Brugnatelli found the ſaccharine acid in the ſaliva of a venereal patient, whoſe diſeaſe was of long ſtanding.

Boerhaave ſays, it promotes the vinous fermentation, on which account the Indian women are accuſtomed to chew the maize before they mix it with water, to promote it's fermentation; it is then uſed as an agreeable drink.

Helvetius the alchemiſt expected to find in it the philoſopher's ſtone.

From the above account of the analyſis of the human ſpittle, little was known concerning it's component parts; but a more detailed analyſis has been made by Hapel de la Chenier on the ſaliva of the horſe, which it will be neceſſary to give ſome account of.

Saliva of the horſe by de la Chenier.

He collected it whilſt the animal was feeding, by making a puncture into the duct of the ſalivary gland; by this means he procured twelve ounces of it in the ſpace of 24 hours.

It's properties when examined externally, and by reagents.

It's colour was of a light greeniſh yellow, ſoapy to the touch; it's aroma weak but diſguſting; it's ſavour ſaline; it's conſiſtence thin, but by repoſe it became leſs fluid.

On expoſure to the air, it became putrid in fourteen days; was covered with a browniſh mouldy pellicle; became thinner, darker, and in ſix weeks was dry, reſembling a blackiſh earth. It does not undergo the acetous previous to the putrid fermentation.

Expoſed to dephlogiſticated air, this fermentation was retarded.

In boiling water it coagulated in part, which coagulum was not ſoluble in water.

Alcohol acted in the ſame manner, and precipitated the coagulable part in the form of flocks, which were not only ſoluble in ammonia but in water.

Vitriolic acid diluted, coagulated it, and the remaining fluid afforded ſmall cryſtals of Glauber's ſalt, after filtration and evaporation.

Nitrous acid made it clammy, and a depoſit ſoon took place.

Marine acid made it tougher, the other acids thickened it more or leſs.

The coagulated part formed by the acids was not ſoluble in water like that procured by alcohol, but ammonia diſſolved it perfectly, and it was again precipitated by acids.

Solutions of the alkalis and neutral ſalts had no effect on this ſaliva; nor did cauſtic alkalis or lime water produce any ſmell of ammonia.

It precipitated metals from their ſolutions.

Earthy neutral ſalts cauſed a depoſit.

Oils and reſins become united with water by ſtirring them with the ſaliva; hence Chenier ſays, that it may ſerve to extract the fat from cloths like a ſoap.

In the heat of boiling water it became thinner and depoſited flocks, whilſt there went over on diſtillation a fluid diſagreeable both in ſmell and in taſte, which was neither acid nor alkaline. The reſiduum reſembled dried mucus, and became moiſt on expoſure to the air; diſtilled in a glaſs retort, it produced a lemon coloured very alkaline fluid, which changed the ſyrup of violets green; and an oil of the ſame colour, which ſwam on the ſurface. In the neck of the retort were cryſtals of volatile alkali, coloured by the oil; a thick, black, empyreumatic oil, which fell to the bottom of the liquor; then inflammable and fixed airs; there remained in the retort a coal, and the inſide was lined with a metallic ſplendour, which remained in it a quarter of a year.

The coal was difficultly incinerated, and the lixivium afforded cryſtals of muriat of ſoda.

Obtained by diſtillation.

He obtained by this diſtilation, of	drm.	grs.
water	1	5
Ammonia - -	0	$3\frac{1}{3}$
Thick empyr. oil -	0	5
Inflam. and fixed air	0	5
Coal - - - -	0	$6\frac{2}{3}$
Total	1	30

It's compoſition.

From Chenier's analyſis, this ſaliva conſiſts of air, water, mineral alkali, common ſalt, and an earth which he takes to be the earth of bones.

Saliva taken from the mouth of the horſe, in which it is mixed with other fluids therein, taſtes very evidently ſaline, and is of a more mucous conſiſtence than the other taken from the duct. It feels very ſlimy, has a nauſeous ſmell, but affords the ſame products by diſtillation as the other. Chenier found, however, that with lime and the cauſtic alkalis it produced a ſmell of ammonia, which was not the caſe with that from the duct.

It's analyſis very imperfect.

From this ſtatement of the analyſis of this fluid, it ſhows how imperfect our chemical knowledge is of it at preſent; a great many more experiments being neceſſary before it's component parts are ſufficiently underſtood.

A great analogy has been obſerved between this fluid and that which is ſecreted from the pancreas; their uſe appears to be the ſame, and both of a ſaponaceous nature.

Plenck's Hygrologie des Menſchlichen Korpers. art. Speichel.—Brugnatelli, in the Journal de Phyſique. p. 214. 1788.—Hapel de Chenier ſur la ſalive d'un cheval, in the Hiſtoire de la Societe Royale de Médecine, à Paris. p. 327, 333. an. 1780 & 1781.—Weber's Unterſuchung der Thieriſchen Feuchtigkeiten. Tubingen. 1780.

TEARS.

Before the experiments of Fourcroy and Vauquelin, this ſecretion had never been analyſed; it is even very difficult to procure a ſufficient quantity of it for examination, which may be one reaſon of it's having been neglected.

Their properties.

The tears, when in a healthy ſtate, are clear and tranſparent as water, they are without any aroma, their ſavour is evidently ſaline.

Their ſpecific gravity is ſomewhat greater than that of diſtilled water.

On expoſure to a dry air, they evaporate ſpontaneouſly to dryneſs; and toward the end, cubic cryſtals ariſe in the midſt of a mucus, which ſerves them as a mother ley. Theſe were found to be the muriat of ſoda, and ſoda in a free ſtate. As the tears thicken on expoſure, they become by degrees more yellow. They undergo no evident change from the impreſſion of heat; on evaporation, the aqueous part firſt comes over, and at the boiling point a foam appears, which is to be attributed to their mucous quality; then an oil, and there remains a dry yellowiſh ſubſtance, ſcarcely amounting to 00,4 of the quantity employed, which is a coal containing the phoſphats of lime and ſoda in ſmall quantity, being ſcarcely perceptible; they have no effect on the tincture of litmus, but change paper coloured by violets to a green, which proceeds from the ſoda.

When freſh, they unite with cold and hot water in all proportions, if, however, they have been previouſly expoſed to the air, ſo as to have received from it a certain conſiſtence and a yellow colour, as before obſerved, they remain unchanged, although from the foamy appearance of the water on agitation, a ſmall portion ſeems to have been diſſolved. By continued expoſure, however, they become leſs and leſs ſoluble, which ſeems to ariſe from their union with oxygen.

Unite with oxygen.

Alkalis unite readily with them, by which they are rendered more fluid, and this is the caſe after they have attracted oxygen.

Of all the acids, the dephlogiſticated muriatic only affords any thing remarkable on this fluid when freſh. It is coagulated by it into white flocks, and becomes yellow as when expoſed to the air; theſe flocks, like inſpiſſated tears, are inſoluble in water. The acid, by loſing it's ſmell and properties, ſhows that it has parted with it's oxygen to the tears, and accounts for the gum which is formed at the angles of the eyes during ſleep.

The ſulphuric and muriatic acids have no effect on freſh tears, but produce an effervefcence when they are oxygenated. In the firſt caſe, ſulphat of ſoda remains mixed with the mucous part; in the ſecond, muriat of ſoda.

Alcohol, added to freſh tears in ſufficient quantity, precipitates the mucous part in the form of large white flocks. If the ſpirit be ſeparated from the mucus and evaporated, traces of muriat of ſoda, and of ſoda, appear, and by this method the proportion between the ſaline and mucous parts may be found.

Analyſis.

From the analyſis made by theſe two chemiſts, it appears that tears are compoſed of a peculiar mucus, which, after their water, forms the greateſt portion of muriat of ſoda, phoſphat of lime and ſoda, which laſt forms ſo ſmall a part as to be ſcarcely perceptible, to which Plenck has added phoſphat of ſoda. From the limpidity of this fluid, it had been conſidered by many as water nearly in a pure ſtate; amongſt theſe was Pierre Petit, a Phyſician of Paris, who publiſhed a Treatiſe on the Tears, about the end of the laſt century. Some obſervers, as Schœner, &c. have likewiſe ſeen the formation of cryſtals in them, and they produce alkali according to Blaſius; but further inveſtigation is neceſſary before we can arrive at their component parts.

NASAL MUCUS.

THIS ſecretion is without ſavour or aroma. It is a tranſparent colourleſs fluid when it is freſh and thin; but when thickened, it is of a ſlight greeniſh yellow.

It's properties.

It's conſiſtence is clammy, adhering to any thing it touches.

This ſecretion is more copious in childhood than at a ſtate of puberty.

It's ſpecific gravity is ſomewhat greater than that of water. It ſwims at firſt on the ſurface of water, but ſinks to the bottom as ſoon as the air is extricated from it.

Expoſed to the air, it becomes hardened into pulverizable ſhining leaflets.

On a red hot coal, it is nearly all evaporated without any diſagreeable ſmell, which is not the caſe when it is united with a little pus.

It neither unites with cold or warm water, nor is diluted by them; neither is it diſſolved by boiling water; ſince, according to Plenck, it falls to the bottom on cooling.

It has no action either on the tincture of litmus, or ſyrup of violets.

It appears to unite, in ſome meaſure, with limewater.

It does not unite oil with water like vegetable mucus.

It is neither ſoluble, according to Plenck, in neutral, nor carbonated alkaline ſalts, but by the cauſtic it is decompoſed.

The acids thicken it ſomewhat in ſmall quantities; in large they diſſolve it, and produce different colours.

The vitriolic acid gives it a purple red colour, and diſſolves it, except a few lumps which fall to the bottom.

The muriatic acid diſſolves it totally, with an amethyſt colour.

The nitrous acid when concentrated diſſolves it with a yellow colour.

Of all animal fluids, it appears to be one that is the leaſt ſubject to putrefaction. It remained a month, according to Plenck, expoſed to warmth in water without any ſmell.

Mucus appears to be the ſame as fibrin of the blood, with this difference, that it contains a little gelatin.

In a diſeaſed ſtate.

For the examination of the naſal mucus in a diſeaſed ſtate, we are indebted to Fourcroy and Vauquelin; the perſon from whom it was taken had an inflammation of the ſchneiderian membrane, or what is commonly called a cold, which is the beſt time to obtain it in any quantity.

At the commencement of this diſeaſe, the mucus is clear and tranſparent as water, it's ſmell ſcarcely obſervable, it's ſavour ſaline and ſomewhat ſharp; in this ſtate it has a great reſemblance in it's properties with the tears; it contains like them muriat of ſoda, ſoda, and ſome particles of phoſphat of lime. To this may be added, that theſe two chemiſts having procured ſome of this naſal mucus quite pure from a perſon who had the inferior extremity of the lacrymal duct obſtructed ſo as to prevent the admixture of the tears, found it perfectly to agree in it's properties with that fluid.

When this humour runs more ſlowly, toward the end of the diſeaſe, it remains longer attached to the ſides of the naſal cavity, and there it undergoes ſeveral alterations; it becomes thickened by the heat of the inflammation, whilſt the inſpired air depoſits a portion of it's oxygen as it paſſes over it, and produces a puriform conſiſtence and yellowiſh or greeniſh colour. On expiration, a part of the carbonic acid uniting with the ſoda of the mucus, gives it the property of precipitating imewater and barytic ſalts.

Since, therefore, the naſal mucus has more conſtantly the acceſs of air than the tears, the laſt being only expoſed to it upon the ſurface of the eyes, and from it can only imbibe the oxygen, it follows that the naſal mucus contains more viſcous matter, has more tenacity than the tears, and on thickening, is generally of a more yellow colour than the tears in the naſal ſack.

Theſe chemiſts found, that the mucus obtained by the inſpiration of dephlogiſticated muriatic acid gas through the noſe had very ſimilar properties to that obtained by a common cold, except that the firſt portions contained no ſoda, nor changed the blue colours of vegetables to a green. At firſt the mucus flowed in great abundance, and was tranſparent as cryſtal; but afterward it became ſomewhat inſpiſſated, and put on the yellowiſh, greeniſh appearance of pus.

From theſe appearances, there is great reaſon to attribute this artificial cold to the oxygen of the marine acid, ſince it was found that the fumes of other acids, which contained no oxygen in a free ſtate, produced no ſuch action.

Plenck, art. Thranen—Examen chimique des Larmes, and de l'Humeur des Narines, &c. par Meſſrs. Fourcroy et Vauquelin. Journal de Phys. Sem. 2. p. 254. 1791. & Annal. de Ch. p. 113. v. 10.

PUS.

THIS, in a healthy ſtate, is a whitiſh fluid, ſecreted from the ſurface of an inflamed part, and is of the conſiſtence of cream. It's properties.

It's ſavour is mawkiſh, and it's aroma when warm is peculiar to it, when cool it is inodorous.

We are informed by Home, that when examined by the microſcope, it is found to conſiſt of two parts, viz. of white globules and a tranſparent colourleſs fluid.

It's ſpecific gravity is greater than that of water.

It does not readily go into the putrid fermentation.

According to Hildebrandt, by a moderate warmth it undergoes the acetous fermentation.

Heat does not coagulate it, but evaporates it to dryneſs.

By the dry diſtillation, Brugmann informs us, it gives an aqueous fluid, which is neither acid nor alkaline, then becomes thick and brown in colour; in a ſtrong heat, it affords an alkaline ſpirit, and ammonia in a fixed ſtate, an empyreumatic oil, and leaves a blackiſh ſhining coal, difficult to incinerate. The aſhes are very ſmall in quanand of a dark reddiſh colour.

When placed on red hot coals, it produces an animal aroma and inflames.

It does not unite with water in the heat of the atmoſphere, but falls to the bottom; if, however, a conſiderable heat be applied, it riſes, and is diffuſed through the water; and remains mixed with it even after cooling, the globules appearing to be decompoſed.

Pus, from a gonorrhœa, and the ſmall or chicken pox, has the ſame appearance as that from a healthy ulcer.

It has no corroding action on fleſh.

It ſhows the preſence neither of a diſengaged acid nor alkali.

Vitriolic acid, when concentrated, diſſolves it, forming a darkiſh purple colour. On diluting the ſolution with water, the dark colour diſappears, and the pus ſeparates again in the form of a porous ſubſtance, part of which ſwims at the top, the other ſinks.

Concentrated nitrous acid produces with it a lemon-coloured ſolution, and the addition of water ſeparates a gray coloured ſubſtance from it.

Strong muriatic acid forms with it an aſh gray coloured ſolution, from which water ſeparates the pus in it's natural ſtate.

Carbonated potaſh, according to Hildebrandt, mixes with pus, and about twelve times as much diſtilled water heated to 100° of Fahrenheit, and becomes of a gelatinous ropy conſiſtence. Bad pus only gives a weak gelatin.

Neutral ſalts have no action upon it.

Cauſtic alkalis form with it a homogeneous, ropy, whitiſh fluid; the pus is again perfectly ſeparated by water and acids.

Alcohol thickens it by attracting it's aqueous particles, but does not diſſolve it.

Oils mix with it, but have no action in their mild ſtate.

Diſtinguiſhed from mucus by Darwin.

Much has been ſaid reſpecting the diſtinguiſhing properties of pus and mucus, and an ingenious Diſſertation has been written by Charles Darwin upon this ſubject, who draws the following concluſions from his experiments: 1. Pus and mucus are both ſoluble in the vitriolic acid, though in very different proportions, pus being much the leſs ſoluble. 2. The addition of water to either of theſe compounds decompoſes it; the mucus, thus ſeparated, either ſwims on the mixture or forms large flocci in it; whereas the pus falls to the bottom, and forms on agitation an uniform turbid mixture. 3. Pus is diffuſible through a diluted vitriolic acid, though mucus is not; the ſame occurs with water or a ſolution of ſea ſalt. 4. Nitrous acid diſſolves both pus and mucus; water added to the ſolution of pus produces a precipitate, and the fluid above becomes clear and green, while water with the ſolution of mucus forms a dirty-coloured fluid. 5. Alkaline lixivium diſſolves (though ſometimes with difficulty) mucus, and generally pus. 6. Water precipitates pus from ſuch a ſolution, but does not mucus. 7. Where alkaline lixivium does not diſſolve pus, it ſtill diſtinguiſhes it from mucus, as it then prevents it's diffuſion through water. 8. Coagulable lymph is neither ſoluble in diluted nor concentrated vitriolic acid. 9. Water produces no change on a ſolution of ſerum in alkaline lixivium, until after long ſtanding, and then only a very ſlight ſediment appears. 10. Corroſive ſublimate coagulates mucus, but does not pus.

The author thinks, therefore, that *ſtrong vitriolic acid* and *water*; *diluted vitriolic acid*; and *cauſtic alkaline lixivium* and *water* will ſerve to diſtinguiſh *pus* from *mucus*; that the vitriolic acid can ſeparate it from coagulable lymph, and alkaline lixivium from ſerum. And hence when a perſon has any expectorated material, the compoſition of which he wiſhes to aſcertain, let him diſſolve it in vitriolic acid, and in cauſtic alkaline lixivium; and then add pure water to both ſolutions, and if there is a fair precipitation in each, he may be aſſured that ſome *pus* is preſent; if in neither a precipitation occurs, it is a certain teſt that the material is entirely *mucus*; if the material cannot be made to diſſolve in alkaline lixivium by time and trituration, there is reaſon to believe that it is pus.

According to Salmuth, who has examined this method of diſtinction, the criterion which that ingenious youth wiſhed to eſtabliſh cannot be relied upon, hence other methods have been propoſed.

Home.

We are informed by Home that the property which characteriſes and diſtinguiſhes pus from moſt of the animal ſubſtances is it's being compoſed of globules. This property was firſt obſerved by John Hunter, and is an accurate means of knowing healthy pus.

Home found that mucus, and every other animal ſubſtance affected by the action of putrefaction, appear to be compoſed of flakes when examined by the microſcope; that this property of being compoſed of globules ſhows that pus has a great affinity to the other animal ſecretions, although in many circumſtances it may differ from them; viz. it differs from the blood in the colour of the globules, in their not being ſoluble in water, whilſt thoſe of the blood are, and from the fluid in which they ſwim being coagulable by a ſolution of ſal ammoniac, which ſerum is not.

It differs from chyle in it's globules being larger; not coagulable on expoſure to the air, nor by heat, whilſt thoſe of chyle are.

The globules of the pancreatic juice are much ſmaller.

Thoſe of milk are nearly of the ſame ſize as thoſe of pus; though much more numerous; but milk coagulates by rennet, which pus does not; and likewiſe contains oil and ſugar, which are not to be diſcovered in pus.

To try the comparative action which pus in the body, and pus and jelly out of it, had on fleſh, Home put a piece of fleſh into a healthy abſceſs, and equal weights of the ſame he immerſed in equal quantities of pus and jelly in two glaſſes, which were kept nearly in the temperature of the human body; and it appeared that in twenty-four hours the fleſh in the abſceſs was quite ſweet; that in the pus had a ſlight putrid ſmell, and had decreaſed in ſize; that in the jelly was become ſmaller and finer in it's texture. In ſix days the fleſh in the firſt was leſſened, but quite ſweet; in the ſecond it was diſſolved in ninety-ſix hours, whilſt that in the jelly was not putrid, but much ſmaller. The muſcle in the abſceſs was preſerved a few days longer without undergoing any change or diminution in weight.

Graſmeyer.

To determine this diſtinction likewiſe between pus and mucus, Graſmeyer has lately propoſed the following experiment. The ſubſtance to be examined is mixed by trituration with an equal quantity of tepid water, a ſaturated ſolution of perfectly aerated potaſh, equal in weight to the ſubſtance, is added, and the mixture being gently agitated is ſet aſide. If the mixture be pus or mixed with it, a tranſparent tenacious jelly will ſeparate in a few hours; on the contrary, if the mixture contain no pus, it will remain unchanged.

On diſtillation Brugmann obtained from 8½ ounces of pus, in a heat of boiling water, 7½ of a tranſparent water without ſmell, which contained neither an acid nor an alkali; by a ſtrong heat, 3 drachms of an empyreumatic ammoniacal fluid; 2 ſcruples of the ſame mixed with an oil, ½ drachm of dry ammonia, and ¾ of an ounce of an empyreumatic oil, and the remaining coal contained, when incinerated, iron, calcareous earth, and no ſalt.

In a diſeaſed ſtate.

In a ſtate of diſeaſe, as in ſcrofulous abſceſſes, pus conſiſts, according to Home, of globules and flaky particles floating in a tranſparent fluid; the flaky part is greater in proportion to the ſmallneſs of the inflammation; and in thoſe abceſſes unaccompanied by inflammation, their whole contents are curdly and flaky; whilſt in irritable ulcers the diſcharge is often thin, being principally compoſed of an aqueous fluid of an irritating nature, and very much inclined to become putrid. According to Crawford, the pus from the cancer conſtantly changed the ſirup of violets green, which he attributes to it's containing ammonia; and potaſh produced no change in it. Sulphuric acid coloured it brown, and diſengaged with an effervеſcence a diſagreeable odour reſembling ſulphureous hydrogenous gas. From his experiments Dr. Crawford concludes, that this pus contains a principle poſſeſſing many properties of hepatic air, which he thinks is combined with the ammonia, and he calls it animal hepatic gas. This pus, diluted with water and diſtilled, afforded at firſt the air of the retort charged with the cancerous odour; this was ſucceeded by ſome whitiſh vapours with a putrid odour. When the water was entirely evaporated, a new gas aroſe exhaling the odour of burnt bones, with ſome empyreumatic oil. It appears, therefore, to Dr. Crawford, that the ſtinking odour of this pus is a volatile ſubſtance, which forms the nidus for the cancerous poiſon.

In the cancer, by Crawford.

Dr. Crawford is of opinion, reſpecting the matter of the cancer, that chemical changes and combinations take place; his reaſons for thinking ſo are, that in the cancer, and in malignant ulcers, the animal fibre undergoes nearly the ſame change as in dry diſtillation. The purulent matter neceſſary to the cure of the ulcer is in this caſe mixed with the animal gas and ammonia.

This compoſition, which may be called an ammoniacal ſulphure, attacks metals and decompoſes metallic ſalts, for when it is encloſed a few days upon mercury, it changes it's ſurface to a black colour, and it immediately precipitates the ſolution of nitrat of ſilver of the ſame colour. Theſe facts appear to Crawford to explain what takes place on applying metallic ſalts to a malignant ulcer, the ammonia unites to the acid of the ſalt, and the hepatic animal gas reduces the metal by ſeizing it's oxygen. (According to Crawford, by reſtoring to it the inflammable principle).

It is probable, that the metal thus reduced is ſometimes attacked again by the ammoniacal ſulphure, which gives it a black colour. The ſame origin may be aſcribed to the black cruſt formed on the tongue and in the mouth, when venereal ulcers of the throat are waſhed with a ſolution of corroſive muriat of mercury; to the obſcure colour which cataplaſms made of the acetite of lead have upon bad ulcers; and to the change which ſounds ſometimes undergo after having been introduced into the ſinuses of ſuch ulcers, or applied to carious bones. Hence, undoubtedly, is the reaſon of poliſhed metals ſo eaſily tarniſhing on expoſure to the putrid effluvia of animal ſubſtances.

Hepatic animal gas, Dr. Crawford found, communicates a green colour to recent fat; it renders animal fibres ſoft and flaccid; it accelerates putrefaction; hence it is a ſeptic, and it is very probable that the compoſition reſulting from it's union with the ammonia, contained in the liquor running from an open cancer, produces deleterious effects and aggravates the diſeaſe. It is the ammoniacal ſulphure that communicates to the cancerous matter it's putrid odour, it's tenacity, and all the properties that diſtinguiſh it from ordinary pus.

According to Dr. Crawford, therefore, a ſubſtance capable of decompoſing the ammoniacal ſulphure, and of deſtroying the fetor of the animal hepatic gas, without increaſing the mortification of the veſſels, would neceſſarily produce ſalutary effects. The nitric acid only deſtroys this fetor at a high degree of concentration, and in this ſtate it is corroſive. On the contrary, this gas is deprived of it's fetor as ſoon as it is mixed with the oxygenated muriatic acid, even diluted with three times it's weight of water; the application can then be made without danger, provided the cancerous ulcer be not very irritable.

In the hoſpital ſore by Cruickſhank.

The matter of the *hoſpital ſore*, which is produced, according to Dr. Rollo, by a poiſon *ſui generis*, as are the venereal, ſcrofulous, cancerous, and variolous ſores, has been examined by Cruickſhank.

This matters appears to be ſparingly ſoluble in water, but being readily diffuſed through it produces a milkineſs.

It produces no effect on the infuſions of litmus or Braſil wood, hence is neither acid nor alkaline.

Pure ammonia reduces it to a tranſparent jelly, and after ſome time diſſolves the greater part of it; the ſame happens to pure pus.

Acids, and particularly the ſulphuric, precipitate but partially theſe ſolutions.

The ſolution of nitrat of ſilver, poured into the filtered aqueous ſolution of this matter, occaſions a whitiſh precipitate.

The ſame effect is produced by the nitrat and muriat of mercury; but the precipitate is much more abundant. When pure pus is treated in the ſame manner, theſe precipitates, particularly that by muriat of mercury, have ſomewhat of a different appearance, difficult to deſcribe.

Limewater rather changes it's fetid odour, but does not deſtroy it; ſulphuric acid increaſes it; alcohol, and a ſolution of the oxyd of arſenic in potaſh, produce the ſame effect. This fetor reſiſts the decoction of Peruvian bark; on the contrary, it is deſtroyed by the nitrats and muriats of mercury, by the nitrous acid, but more completely by the oxygenated muriatic acid, either in a liquid ſtate or in the form of gas. The nitrat of ſilver produces very little change either in it's colour or odour, which is the more remarkable from this ſalt having the property of deſtroying the moſt offenſive odours, even that of the matter of the cancer.

Cruickſhank is of opinion, that the bad odour of this matter of the ulcer is produced by a change of one part of the true pus; for every ill conditioned diſcharge has more or leſs ſmell, while good pus has none; and ſince it is a principle in chemiſtry, with only few exceptions, that the odour of a ſubſtance cannot be entirely deſtroyed without changing it's properties at the ſame time, there is reaſon to think, that if the odour of this peculiar morbific matter be entirely deſtroyed by the addition of the nitrat or muriat of mercury, the oxygenated muriatic acid, &c. it's properties will be likewiſe changed.

Suppoſing then, that an acid matter produced by ſome means on the ſurface of a ſore is able to produce ulceration of a ſpecific kind, and that this ulceration, like that of the venereal viſcus, is able to propagate itſelf by forming a ſimilar matter, or even to induce a general affection of the ſyſtem; there are ſeveral important conſequences might be drawn from theſe experiments.

1ſt. A ſore, once clean, might be preſerved from the effects of the matter alluded to, and even it's generation prevented, by waſhing it at every dreſſing with a weak ſolution of nitrat of mercury, or with the oxygenated muriatic acid.

2d. When this matter begins to form, it's progreſs may not only be ſtopped, but that already formed may be deſtroyed by the application of a proper topic. In this caſe, the above experiments ſhow, that the moſt preferable are the moſt active mercurial preparations, ſuch as the muriat of mercury, or the precipitated red oxyd of the nitrat of mercury, which has not been entirely edulcorated. If it be neceſſary to employ actual cauſtic, the beſt method is that of Humpage, which conſiſts not in the application of the nitrat of ſilver, but in applying to the part a ſmall piece of linen dipped in ſome concentrated nitrous acid, which occaſions leſs pain than the other.

Reſpecting the action of different ſubſtances employed as cauſtic applications on ſores, they may be diſtinguiſhed into four.

1ſt. Subſtances producing a violent action, ſo as to occaſion the death of the part to which they are expoſed, ſuch as

Arſenic,
Muriat of mercury.

2d. Subſtances acting ſimply by burning or deſtroying the part, the action of which is always limited, as

Nitrat of ſilver,
Nitrat of mercury,
Nitric acid.

3d. Subſtances acting as menſtrua, the action of which it is difficult to limit, as

Common lunar cauſtic,
Mixture of potaſh and lime.

4th. Subſtances acting chemically on the part, by decompoſition as

Oxygenated muriatic acid, either
united with water or
in a ſtate of gas.

Dr. Rollo. We are informed by Dr. Rollo, that by chemical means he was ſo fortunate as to deſtroy the morbid poiſon of the hoſpital ſore; for this purpoſe he made uſe of the oxygenated muriatic acid, the nitrats of ſilver and of mercury, and the oxygenated muriatic acid gas. He began by waſhing the ſore with warm water; the ulcerated part was then immediately touched with the nitrat of ſilver; the ſore was afterward moiſtened with a diluted ſolution of nitrat of mercury, or a mixture of oxygenated muriatic acid and diſtilled water, and the whole was then covered with a linen cloth which had imbibed both. The oxygenated muriatic acid gas was alſo applied to the ulcer, and the diluted ſolution of nitrat of mercury on the whole of the ſore. By this treatment the ſore ſoon became cicatrized, and it only failed when the ulcer was too extenſive to be entirely acted upon by the nitrat of mercury or the oxygenated muriatic acid gas.

Home on Ulcers.—Hildebrandt's Anfangsgrunde der Ch.—S. I. Brugmann, Diſſertat. de Puogenia. Gron. 1785.—Experiments eſtabliſhing a Criterion between mucaginous and purulent Matter, by Charles Darwin. Litchfield, 1780.—Henr. Salmuth de Diagnoſi Puris. Goett. 1783.—Hermann Graſmeyer's Abhandlung von Eiter and den Mitteln ihn von allen andern Feuchtigkeiten zu unterſcheiden. Gottingen, 1790.—Pus of the Cancer by Dr. Crawford, Annales de Chim. tom. 12. p. 149.—An account of two caſes of the Diabetes mellitus, by J. Rollo, M. D. with the reſults of the trials of various Acids and other Subſtances, in the treatment of Lues venerea, by Wm. Cruickſhank, 2 vol. Dilly, London, 1797, and Annal. de Ch. No. 86, p. 209.

SYNOVIA.

THIS is a tranſparent glutinous fluid, which is ſecreted between the articulations of animals to preſerve them from friction. The nature of this fluid was very little known before the experiments of Marqueron on that of the ox.

It's properties.

It is of a whitiſh green colour, has an animal aroma reſembling that kind of mucus found on the exterior of frogs.

It's ſavour ſomewhat ſaline.

It's ſpecific gravity is greater than that of diſtilled water. On being taken from the joints it becomes of a gelatinous conſiſtence, but does not continue long ſo, it is then as tenacious as before; at laſt it is fluid and gives a depoſit. If, however, it be filtrated on being received from the joints, it does not become gelatinous.

It changes green the blue colour of vegetables, and precipitates lime from it's aqueous ſolution.

It unites with water and makes it gelatinous; even one part of ſynovia gives ſix parts of water very evidently this property. The mixture effervеſces on agitation; if boiled, it loſes it's tranſparency and receives a milky colour, and there ariſes to the ſurface a coagulated lymph; but although one part of the glutinous maſs has been thus ſeparated by boiling, the mixture ſtill retains a glutinous appearance. If a very diluted acid be added to this mixture, there ariſes a ſingular effect, whether in the warm or cold way. It becomes in an inſtant quite tough, which toughneſs it loſes on being ſtirred. It then becomes clear and tranſparent, and a peculiar ſubſtance ſeparates which is gluey and elaſtic. For this experiment vinegar is the beſt, as a concentrated acid cauſes no ſeparation. The remaining liquor ſtill retains ſome albuminous matter, which on evaporation appears in the form of a pellicle.

Carbonated alkalis mix readily with ſynovia; but cauſtic render it fluid.

Concentrated acids precipitate a flocky ſubſtance from it, which is ſoluble again in the acid. When diluted, they coagulate it.

Alcohol, without depriving it of it's glutinous appearance, likewiſe ſeparates a flocky matter from it.

By diſtillation it ſhows nothing peculiar; there ariſes a water which eaſily putrifies, an empyreumatic oil, and ammonia. In the remaining coal alkali and muriat of ſoda are found on lixiviation; and when incinerated the aſhes afford phoſphat of lime.

Hence it ſhows the properties of the white of the egg. It is ſoluble in water and in an alkali, with which laſt it effervesces on agitation; it coagulates by heat or by acids or alcohol; but it appears to demand further inveſtigation, ſince it is a peculiar liquor that contains two ſpecies of albumen: 288 grains of ſynovia by chemical analyſis afforded

Analyſis.

Albumen in a peculiar ſtate	34 grs.
Common albumen	13
Muriat of ſoda	5
Carbonat of ſoda	2
Phoſphat of lime	2
Water	232
	288 grs.

According to Hatchett, 480 grains of ſynovia did not yield more than one grain of phoſphat of lime.

Mémoire ſur l'Examen de la Synovie, par M. Margueron, Journ. de Phys. ſem. 2. p. 463. an. 1792.

SPERMA VIRILE.

The component parts of this ſecretion were but little underſtood before the experiments of Vauquelin, which have not, however, thrown any light on the cauſes of it's very extraordinary properties.

Semen, as it comes from the body of a young healthy perſon, preſents itſelf under two forms: one part is fluid and milky, and the other of the conſiſtence of a thick mucus, in which is to be obſerved a number of white ſhining threads, more particularly if it be agitated in cold water. Conſiſtence.

According to Plenck, it is yellowiſh in the teſticles, and of a dark yellow colour in the veſiculæ ſeminales; by frequent emiſſion it is whitiſh. In perſons under the jaundice, and thoſe who have taken ſaffron, it is yellow, whilſt in a perſon who had the black jaundice it was black.

Lewenhöeck, Hartſöecker, Baker, Haller, Buffon, and Spallanzani, have amuſed themſelves with the examination of this liquor under the microſcope, in which they obſerved numberleſs animalcula or vermiculi, the laſt has even written their hiſtory, whilſt various theories have ariſen from the ſpeculative mind of genius, to account for the proceſs of generation from the appearance of ſuch minute beings. Examined by the microſcope.

In Roſier's Journal de Phyſique for January 1784, p. 437, is a memoir in which the author obſerves, that if this liquor be examined from the 12th to the 72d hour after it's extraction, and before it becomes putrid, and is in a tranquil ſtate, from the death of theſe animalcula, each drop is found to contain a number of very ſmall, light, brilliant cryſtals, either ſwimming on the liquor Cryſtallization.

or ſuſpended in it. This experiment muſt be tried in a place where no duſt can moleſt it, and where the heat is neither above 25° nor below 5° of Reaumur. Theſe cryſtals are ſpindleſhaped, or rather conſiſt of cones oppoſed at their baſis, and the ſides of which, inſtead of being ſtraight lines are rather convex ; ſome are iſolated, others in groups, their dimenſions varying from $\frac{1}{50}$ to $\frac{1}{300}$ of a line in a diameter. Some of theſe are even ſo large as to be ſeen by the naked eye ; they neither deliqueſce nor effloreſce. It appears that this ſaline ſubſtance is not found until after a certain degree of ſpontaneous evaporation. Theſe cryſtals ſeem to have eſcaped the obſervation of Haller, and ſome other natural philoſophers who have examined this liquor. They ſaw no cryſtals, although they were very deſirous to complete it's analyſis. He tells us, that this liquor, diſtilled in a ſand bath, afforded a phlegm, a quantity of fetid oil, a little volatile ſalt, and a good deal of earth. We are, however, not informed of what this volatile ſalt was compoſed ; it could not be the cryſtallized ſalt above mentioned, which appears to have been a neutral ſalt, nearly inſoluble in alcohol, not volatile, far from deliqueſcing, and only ſoluble in a very large quantity of water ; it likewiſe appears to exiſt entirely developed in the ſeminal liquor, in which there could be no appearance of ammonia at ſo early a period. Theſe cryſtals, however, which the author of the memoir appears to be ſo deſirous of being brought to light, are moſt probably the ſame which Vauquelin found in his examination, an account of which will be given.

Experiments according to Vauquelin.

It's properties.

According to Vauquelin, the ſavour of this fluid when freſh is ſharp, pungent, and ſomewhat aſtringent, contracting the organs of taſte ; it's aroma is inſipid, like that of moſt other animal ſubſtances. On the contrary, we are told by Plenck, that it's aroma is of a peculiar kind, very ſtrong to the organs of ſmell, and not unpleaſant. That the ſame ſmell is found in the roots of orchis, in the down of cheſnuts, and in the anthers of ſeveral plants. In ſome quadrupeds, this aroma is ſo ſtrong and penetrating in the ſeaſon of their amours, as to taint the fleſh ; hence the fleſh of the goat at this period is not eatable.

With reſpect to it's ſpecific gravity, it differs according to circumſtances, but it is always heavier than diſtilled water, in which it immediately ſinks to the bottom if it has not previouſly imbibed a few particles of air. If rubbed in a mortar it becomes pituitous and thick, reſembling pomatum, which Vauquelin attributes to the admixture of air. When freſh, it changes the blue colours of vegetables to a green, and precipitates calcareous and metallic ſalts from their ſolutions, all which indicate the preſence of a diſengaged alkali.

Curious appearance.

The thick mucous part of the ſemen, on loſing a part of it's caloric, becomes tranſparent and of more conſiſtence than when juſt emitted ; but it's greateſt peculiarity is, it's becoming fluid again in a few hours when cool. It likewiſe diminiſhes in weight in proportion to the loſs of caloric, &c. Theſe appearances are not to be accounted for from the knowledge we have of this fluid at preſent.

Expoſed to an air of 10° or 12° of Fahrenheit, after having undergone this change to a fluid ſtate, it becomes covered with a tranſparent pellicle, and after three or four days Vauquelin found a depoſit of ſome very delicate tranſparent cryſtals, about a line in length, ſome of them in a cruciform poſition. Examined by a magnifier, theſe cryſtals appeared in the form of quadrilateral columns, terminated by very elongated quadrilateral pyramids, and were phoſphorated calcareous earth, which it had previouſly held in ſolution. In a few days more this pellicle becomes thicker, full of white round corpuſcles; the liquor becomes more fixed, and it's aroma ſomewhat reſembles ſweet whey. If from the ſtate of the atmoſphere the evaporation goes on very ſlowly, other cryſtals form of different ſhapes. Sometimes they are rhomboidal plates, at other times ſix ſided or rectangular priſms, or octoedral, and Vauquelin found them to be ſoda which had united with the carbonic acid of the atmoſphere. At the temperature of 18° or 20° this ſemen becomes ſemitranſparent like horn, and ſnaps between the fingers.

If the temperature be greater, as at 20° of Reaumur, the air moiſt, as at 75 of the hygrometer of Sauſſure, it is changed before it has time to evaporate to dryneſs; it becomes yellow like the yolk of an egg, ſour, and ſmells like putrid fiſh. Vauquelin, likewiſe, found it covered with the byſſus ſeptica.

Caloric has very little ſenſible action upon freſh ſemen; it only accelerates it's liquefaction, and when in this ſtate it does not coagulate it, as it does many other animal ſubſtances.

If the caloric applied be ſo great as to ſeparate it's principles, the aqueous part is firſt expelled, it then becomes evaporated to dryneſs, ſwells, blackens, emits yellow empyreumatic ammoniacal vapours, and leaves a light eaſily inflammable coal, which, by lixiviation and evaporation, affords rhomboidal cryſtals of carbonat of ſoda, and the remainder, on incineration, is reduced to white aſhes which contain phoſphat of lime.

Freſh ſemen is not ſoluble either in cold or hot water, but when evaporated to dryneſs it is ſoluble in both, and it is ſeparated from them in the form of white flakes, either by alcohol, or dephlogiſticated muriatic acid, Acids diſſolve it, and the ſolution is not afterward decompoſed by alkalis.

Coagulated by dephlogiſticated muriatic acid.

The dephlogiſticated muriatic acid is, however, an exception; for inſtead of diſſolving freſh ſemen, it coagulates it into white flakes, which are inſoluble in water or acids. The ſame takes place if the ſemen be in a liquid ſtate. It is obſerved by Vauquelin, that a large quantity of the acid gives it a yellow colour, like the thin matter of a gonorrhœa; this is owing to the fixation of the oxygen, for the acid loſes it's odour afterward.

Alkalis, when ſufficiently ſtrong, facilitate it's union with water.

Lime has no effect on freſh ſemen, but after it's expoſure to a moiſt atmoſphere for ſome time, a conſiderable quantity of ammonia is produced.

Neutral ſalts are not decompoſed by it even in a liquid ſtate; but the caſe is otherwiſe after a long expoſure to the air when the rhomboidal cryſtals are formed.

It's analyſis.

According to Vauquelin's analyſis, one hundred parts of human ſemen contain of

Water	90
Fibrin	6
Soda	1
Phoſphat of lime	3
Total	100

Concluſion.

From the facts already mentioned in the inveſtigation of this animal ſecretion, it appears, that there are many curious circumſtances attending it,

1. It's becoming fluid out of the body.
2. It's inſolubility in water before it's fluidity, and it's ſolubility afterward.

Theſe two properties, Vauquelin is of opinion, ariſe from it's animal and mucilaginous nature.

3. The ſolubility of the phoſphat of lime in this liquor.

4. It's cryſtallization by ſo moderate an evaporation.

Obſervation ſur la Liqueur ſeminale, Journal de Phyſique, p. 437. Jan. 1784.—Expériences ſur la Sperme humaine, par M. Vauquelin, ibid. p. 58. ſem. 2. 1791.—Tracts on the nature of Animals and Vegetables, by Spallanzani. Creech. 1799.

HUMOR A VESICATORIO.

It is a well known fact, that when cantharides are applied to the ſkin in the form of a plaſter, an elevation of the cuticle takes place, and the bliſter is filled with a fluid reſembling water in it's external appearance. For the examination of this ſerum or ſeroſity, as it has been called, we are indebted to Margueron. His principal intention was to diſcover it's nature, and to what claſs of humours it belonged; on which account he analyſed it both in a ſtate of health, and when taken from patients labouring under putrid fevers. He found that by frothing with water, by it's coagulation with alcohol, boiling water, acids and heat, and from the different ſalts it contained, it reſembled the ſerum of the blood; and on comparing them together, he concluded that the great difference between them conſiſted in the odour and colour, the ſeroſity being of a darker or amber colour, and poſſeſſing the ſmell of the bliſtering plaſter. The fluidity of the ſerum, however, was more viſcous, whilſt the ſeroſity on coming from the veſicles afforded a pellicle. The ſpecific gravity of the ſerum to the ſeroſity was as 305 to 300, and 200 parts of each gave, on analyſis, the following proportions.

Examined by Margueron.

Reſembles the ſerum of the blood.

Difference.

Analyſis.

	SERUM.	SEROSITY.
Albumen	40	36
Muriat of ſoda	4	4
Carbonat of ſoda	3	2
Phoſphat of lime	2	2
Water	151	156
	200	200

This chemiſt is of opinion, that the colour is cauſed by the action of the veſicatory in exciting heat, inflammation, &c. as he found the colour the ſame whether it was procured from a healthy or diſeaſed perſon. From theſe experiments, therefore, it appears, that the seroſity and ſerum are ſimilar in their properties and both extracted from the blood.

This analogy induced this chemiſt to examine that ſeroſity or aqueous fluid produced by ſinapiſms, by burns or ſcalds, and by the ſting of inſects, or by the ant, as well as that which is the effect of cutaneous diſeaſes; and he found on ſubmitting them to experiment, that they had all the ſame properties as the ſerum of the blood, and conſequently that all aroſe from the ſame origin.

Examen chimique de la Séroſité produite par les Remèdes véſicaires, par M. Margueron. Annal. de Ch. tom. 14. p. 225.

HUMOR HYDROPIS.

Refembles the laſt.

THE fluid which is ſecreted in the various ſpecies of dropſies of the body, is likewiſe ſimilar to the laſt mentioned liquid. It is in general ſomewhat yellow, ſcarcely turbid, and reſembles even in it's external appearance the ſerum of the blood. It has a peculiar ſmell, which in ſome caſes, as in the milk fever, is apparently acid. It is ſaline to the taſte, and tinges violets green. Left to itſelf, it firſt becomes turbid, and at laſt putrefies. Boiling water coagulates the greater part of it; poured into hot water it forms a milky fluid which is incoagulable by nitric acid. It is alſo coagulated by all acids; alkalis rather dilute it, and when mild, precipitate in a few hours a gelatinous ſubſtance which is conſidered as a proof of the preſence of pus. The white, opake, and ſeemingly unctuous membrane (pſeudomembrana Ruyſchii) which often accompanies this humour in dropſies, agrees in it's properties with the fibrous part of the blood, and with it's buffy coat. By heat, or expoſure to air, it dries into a horny ſubſtance, but in moiſt air it ſpeedily putrefies. When triturated with water, it forms an imperfect ſolution, from which mild alkalis precipitate a gelatinous matter.

Jacquin's Elements of Chemiſtry. p. 363. 1799.—Buckholz Chemiſche Unterſuch. der Feuchtigk. von einem Waſſerſucht. Crell's Annal. 2. 1786.

LIQUOR AMNII.

Haller's opinion.

It is ſtated by Haller on the authority of ſeveral reſpectable authors, that the human liquor amnii is not very unlike the ſerum of milk in it's properties, even in it's odour; that it is ſomewhat ſaline to the taſte, and is coagulated by alum, alcohol, and the infuſion of galls. Some authors who look upon this fluid to be the food of the fœtus in utero, are likewiſe inclined to believe that it has all the properties of albumen or the white of the egg, which is the nouriſhment of the chicken before it breaks the ſhell, and ſo far it favours their hypotheſis; great care ſhould however be taken in making experiments of this kind, that the mind be unbiaſſed by any previous prejudice, as in ſuch caſes it often is apt even to deceive itſelf.

Van der Boſch.

A few years ago, this aqueous fluid was chemically examined by a Dutch chemiſt, Van der Boſch, whoſe veracity is as much to be relied upon as that of thoſe quoted by Haller, or thoſe authors who have written ſince upon the ſubject. This chemiſt applies the fruit of his experiments to phyſiology, and attempts to prove that the fœtus in utero receives no nouriſhment from this fluid.

He examined the liquor amnii of the cow and that of the human female, and found that it's quantity is in the inverſe proportion of the ſize of the fœtus, and that in the firſt ſtage of pregnancy it's weight exceeds that of the fœtus from twenty to one hundred times. It's colour during the firſt months is clear, or has a ſlight yellow hue, but towards the birth, it is turbid, flocky, and ſometimes has a reddiſh tinge. It's ſmell is ſcarcely obſervable, reſembling the ſteam of a newly-ſlain animal. It's ſpecific gravity is not very different from that of common water, but at birth it is ſomewhat heavier and gives a copious depoſit. From experiments, it conſiſts for the moſt part of mere water, and is of all animal fluids the moſt aqueous. It does not coagulate by any means. It contains an exceedingly ſmall quantity of common ſalt and fixed alkali, and a very little phoſphoric acid. It produces leſs volatile alkali and empyreumatic oil than any other animal fluid. It contains a little earth and red calx of iron, and the conſtituent parts and properties of that of the cow in the firſt months of pregnancy were found perfectly to agree with that of the human female, procured at the time of delivery, except that it is more aqueous.

From theſe facts, the author concludes, that although the liquor amnii has been commonly compared to the white of the egg; yet this laſt coagulates by heat and acids very readily, the liquor amnii not at all; and for the ſame reaſon it differs from ſerum of the blood, and the liquor pericardii.

It does not agree with whey, for this laſt contains a large quantity of an eſſential ſaccharine ſalt, the liquor amnii none at all.

It differs from animal broth or ſoups, for it does not coagulate in the cold, or undergo the acetous fermentation.

Laſtly, it differs from urine, for it ſcarcely contains an atom of volatile alkali, whilſt urine affords it in large quantity; and the author affirms that it's uſe is to protect the fœtus from external preſſure; that it aſſiſts in expanding the womb, renders the parts ſupple, and is of great ſervice at the time of delivery.

With reſpect to the coagulation of this fluid, it appears from the experiments of John Hunter, that it contains but a very ſlight quantity of matter coagulable by heat.

John Hunter.

The moſt perfect and detailed analyſis of the liquor amnii, has been made by Buniva and Vauquelin; they not only examined that of the human female, but likewiſe that of the cow. Suppoſing there would be great ſimilarity between the liquor amnii of different animals, they began with the human, but they ſoon found that no ſuch reſemblance exiſted, aud that no two things were more unlike than the human and that of the cow.

Buniva and Vauquelin.

LIQUOR AMNII OF THE HUMAN FEMALE.

Human liquor amnii.

It's properties.

1ſt. It has a mild and inſipid odour like all the white fluids of animals.

2d. A ſlightly ſaline ſavour.

3d. It's colour is ſomewhat milky, owing to a caſeous matter which is ſuſpended in it, for it may, by filtration, be obtained clear and tranſparent.

4th. It's ſpecific gravity is as 1005.

5th. It foams conſiderably on being agitated.

6th. On expoſure to heat, an opacity is produced reſembling that of milk greatly diluted with water, and a ſmell of the boiled white of an egg.

7th. It ſtrongly changes the tincture of violets to a green, but ſlightly reddens the tincture of litmus.

8th. Potaſh produces a flaky precipitation of animal matter, which ſeems to have been diſſolved by a ſlight acid.

9th. Acids only clarify it.

10th. Alcohol produces a flaky precipitation, which being collected and dried, is brittle and tranſparent as glue.

11th. A very large brown precipitate is formed with the infuſion of galls.

12th. The nitrat of ſilver produces a white precipitate, inſoluble in the nitric acid.

From theſe properties, theſe two chemiſts conclude that the human liquor amnii contains,

1ſt. An albuminous matter reſembling that of the blood, appearing to be held in ſolution by a ſlight acid.

2d. A muriatic ſalt, with ſoda for it's baſis.

3d. A ſmall proportion of alkaline matter. It appears difficult to admit the preſence of an acid and an alkali at the ſame time in this liquor, in a free ſtate; and indeed theſe chemiſts do not ſay there is really an acid, but that it acted as if it contained one, for it reddens the tincture of litmus, is precipitated by cauſtic potaſh, and depoſits by fermentation an earthy animal matter, from which ammonia is extricated.

Evaporation of it.

On evaporation, the liquor amnii, 1ſt. becomes ſlightly milky. 2d. There ariſes a tranſparent pellicle on it's ſurface. 3d. A reſidue is left, the weight of which at moſt amounts to 0,012 of the whole.

The edulcorated reſidue, on evaporation, afforded cryſtals of muriat and carbonat of ſoda. The animal matter, lixiviated, gave, on being burnt, a fetid and ammoniacal odour, nearly like that from horn; there remained a few aſhes compoſed of carbonat of ſoda, of phoſphat and carbonat of lime.

It's component parts.

Theſe experiments prove that the human liquor amnii only contains a very ſmall portion of ſaline and animal matter, diſſolved in a large quantity of water, ſince the different ſubſtances together ſcarcely amounted to 0,012 of the liquor, and theſe are albumen, ſoda, muriat of ſoda, and the phoſphat of lime.

The liquor amnii kept in a cloſed bottle undergoes in the courſe of a few weeks a putrid decompoſition; it loſes it's tranſparency, and depoſits a white matter like cheeſe. During this change, a little ammonia is evolved, but no gas or bad ſmell. Putrid fermentation.

CASEOUS MATTER.

Caſeous matter.

This ſubſtance is white and ſhining, ſoft to the touch, and reſembling newly made ſoap. It is inſoluble in water. Alcohol, even with the aſſiſtance of heat, has no effect upon it. Oils do not unite with it. Cauſtic alkalis diſſolve a portion forming with it a kind of ſoap, at leaſt judging from it's odour, ſavour, and the property of being precipitated by acids. It decrepitates like ſalt upon red hot coals, then becomes dry, blackens, and ſends forth empyreumatic oily vapours. Laſtly, a large quantity of coal is left difficult to incinerate. It's properties.

Heated in a crucible of platina, it likewiſe decrepitates, and an oil exudes from it. It ſhrivels like horn, inflames, and leaves a gray cinder that effervefces with acids, the greater part of which is compoſed of carbonat of lime.

From theſe properties it would appear, that this caſeous ſubſtance is a mixture of animal mucilage and fat; but it is more probably a peculiar ſubſtance, the origion of which theſe chemiſts attribute to a degenerate ſtate of the albuminous matter, taking a fat character. This change is not more extraordinary than the converſion of the fœtus into fat on remaining in the uterus beyond the natural time. It's compoſition.

It is this kind of matter which is found depoſited upon the body of the fœtus, particularly under the armpits, behind the ears, and on the groins, where it is ſometimes Utility of it.

in large quantity. It ſerves by it's ſoftneſs, unctuoſity, and it's impenetrability to water, to anoint the ſkin of the fœtus, and prevent any bad effects of the liquor amnii; at the ſame time it favours it's birth during delivery.

LIQUOR AMNII OF THE COW.

Liquor amnii of the cow differs from the human.

This liquid differs from that of the human ſubject, 1ſt. By a fallow red colour. 2d. An acid ſavour mixed with a bitterneſs; an odour reſembling certain vegetable extracts. 3d. A ſpecific weight equal to 1.028, and by a viſcoſity approaching that of a ſolution of gum.

Properties of it.

1ſt. It reddens ſtrongly the tincture of litmus.

2d. It forms a large precipitation with the muriat of barytes.

3d. Alcohol ſeparates a large quantity of reddiſh matter from it.

Evaporation.

On expoſing the liquor amnii of the cow to evaporation, a thick foam was formed, eaſy to ſeparate, in which, when cool, ſome white ſlightly acid cryſtals were obſerved. It became thick, viſcous, and yellow, like a kind of honey, of which it had nearly the ſhade. Treating this matter with boiling alcohol, it afforded an acid, which, on the cooling of the liquor, cryſtallized into ſhining needles, ſeveral centimetres in length. The extractive ſubſtance being inſoluble in alcohol, remains in the form of a gluiſh compact pitch. In order to deprive it completely of it's acid, it is neceſſary to boil it ſeveral times in a large portion of alcohol, and by evaporating the menſtruum, the acid it diſſolves is obtained.

An acid obtained, the amniotic.

To prevent any of the extractive matter from being diſſolved with the acid in the alcohol, the liquor amnii muſt be evaporated to a thick conſiſtence, for humidity favours it's ſolution. It was by treating in this manner the reſiduum, that theſe chemiſts diſcovered an acid in this liquor; but they found afterward that alcohol was not neceſſary to ſeparate it, that it was ſufficient to reduce the liquor to one fourth, to obtain, on cooling, the greater part of the acid. It is indeed much whiter and purer when extracted by alcohol, from being deprived of all the animal matter that may remain attached to it's cryſtals, formed in a thick fluid; but it can be purified by waſhing it with a little cold water, which readily diſſolves the extractive matter, and ſcarcely at all the acid. (*Vide* acids, amniotic acid.)

The liquor amnii being deprived of it's acid, if the evaporation be continued until it has acquired the conſiſtence of ſirup, large tranſparent cryſtals are formed that are very ſoluble in water and of a bitter colour. Theſe chemiſts found it to be the ſulphat of ſoda. It is in pretty large quantity. To obtain it pure they burnt the reſiduum of the exſiccated liquor, and by lixiviating the aſhes, obtained a ſolution which afforded on evaporation perfectly pure cryſtals of this ſalt.

THE EXTRACTIVE ANIMAL MATTER.

The animal extractive matter.

THE animal matter which accompanies the above ſalts in the liquor amnii of the cow, theſe chemiſts found to be of a peculiar nature, with no perfect reſemblance o any at preſent known.

It's properties.

It is of a brown red colour, has a ſingular ſavour difficult to deſcribe; it is very ſoluble in water, and inſoluble in alcohol, which even ſeparates it from the water. This laſt property, with that of giving viſcoſity to water, and the faculty of foaming on agitation, ſeems to give it a relation to mucous ſubſtances; but it differs from animal mucilages by not being convertible into a jelly, and not combining with tan; beſides, the ammonia, the pruſſic acid, and the empyreumatic oil, prevent it's being looked upon as a vegetable mucilage. Expoſed to the fire, it ſwells very much, emits at firſt an odour like burnt mucilage, afterward that of an empyreumatic and ammoniacal oil; laſtly, the odour of pruſſic acid is ſtrongly perceived. After inflammation, it leaves a very voluminous coal, eaſily incinerated; the aſhes are very light and of a beautiful white colour; are ſoluble in acids without effervefcence, and formed of phoſphat of magneſia, and a very ſmall quantity of phoſphat of lime This animal matter is decompoſed by the nitric acid, but it does not form (at leaſt in any obſervable quantity) any vegetable acid, which is the caſe with the greater part of ſubſtances belonging to the organic kingdom; during it's action, carbonic acid and azot gaſes are formed, mixed with nitrous gas.

Compoſition.

Such are the principal facts relative to the principles contained in the liquor amnii, the formation of which is at preſent unknown.

Haller's Phyſiol.—Diſſertatio Chem.—Phyſiolog. de Natura & Utilitate Liquoris Amnii à Hubertus Van den Boſch. p. 54. Utrecht, 1792.—Extrait d'une Mémoire ſur l'eau de l'amnios de femme et de vache, par les Cits. Buniva et Vauquelin. An. de Ch. No. 99. p. 269. 1799.

SOLIDS.

Their diviſion into red and white.

ALTHOUGH the ſolids may be ſaid to form the greateſt part of the animal body, their component parts are much leſs known, and their analyſis much leſs advanced than that of the fluids, or perhaps of any other parts that have yet been ſubmitted to chemical inveſtigation. They have been divided by authors into red and white parts; amongſt the firſt, the muſcles or fleſh and the liver have as yet only been examined; the ſecond diviſion comprehends the brain, ſkin, the cartilages, tendons, ligaments, cellular membranes, the aponeuroſis, and perioſteum.

1. Red parts. Theſe derive their colour from the red particles of the blood, which circulate in their veſſels; whilſt in animals, in which the red particles are not permitted to circulate, the muſcular parts are of a white colour, as is the caſe in the generality of fiſhes, &c.

MUSCLE OR FLESH.

Muſcle examined by Neumann.

NEUMANN, who ſubmitted different kinds of fleſh to diſtillation on the open fire, obtained from them the common products of animal ſubſtances, *i. e.* more or leſs of what he called an urinous ſpirit, volatile ſalt, and an empyreumatic oil; whilſt the black coal remaining behind afforded a fixed ſalt.

He was of opinion, that the nutritious matter of animal fleſh is a ſubſtance of the gelatinous kind, and that water, by long boiling, diſſolves and extracts it much more readily and completely from ſome ſorts of fleſh than from others. This author gives us the method of making portable ſoup; as he informs us, that if the coction be performed in cloſe veſſels, and the liquor properly evaporated to a due conſiſtence, a ſolid extract may be obtained, which is a very ſerviceable preparation, for when thoroughly dried it keeps well, and may be again diſſolved by warm water into a liquor reſembling the ſoup or freſh decoction.

Geoffroy. According to the experiments of Geoffroy on a pound of the fleſh of the ox, ſheep, and calf, it appears, that the fleſh of the firſt affords the leaſt ſoluble ſubſtance, and that the proportion of the extract and fibrous part inſoluble in water, as well as of the humidity contained in them, is the following:

	Ox.			Sheep.			Calf.		
	oz.	drs.	grs.	oz.	drs.	grs.	oz.	drs.	grs.
Solid extract -		7	8	1	3	16	1	1	47
Humidity or phlegm	11	6	64	11	5	32	11	6	44
Dry fibres - -	3	2	0	2	7	24	2	7	32
	16 or 1 lb.			Do.			Do.		

The muſcles of animals are compoſed of a parenchymatous and a cellular part, in which different humours are contained, partly in a concrete, and partly in a fluid ſtate. Theſe humours conſiſt, 1. Of a red and white albuminous fluid. 2. Of a gelatinous mucilage. 3. Of a mild oil of the nature of fat. 4. Of a peculiar extractive ſubſtance. 5. Of a ſaline matter, the nature of which is very little known.

The analyſis of the whole ſubſtance of the fleſh, which affords, by diſtillation on the water bath, a vapid water, an alkaline phlegm, an empyreumatic oil, and carbonat of ammonia, and which leaves a coal from which a little fixed alkali and muriat of potaſh or ſoda may be extracted by incineration, affords no exact knowledge of the nature of the different principles; hence it is neceſſary to have recourſe to means, by which theſe ſubſtances may be extracted without obliging them to undergo a change of compoſition, and which afford an opportunity of examining them ſeparately.

Thouvenel.

To obtain and ſeparate theſe different ſubſtances, Thouvenel made uſe of a preſs by which the fluid parts were ſqueezed out of the muſcle; he then employed the action of fire to coagulate the albuminous part, and obtained the ſalt by evaporation; of water, to diſſolve and ſeparate the gelatinous mucilage, the ſalt, and extract; and of alcohol, to get the two laſt principles without the jelly. It is, however, very difficult to ſeparate all theſe different matters exactly, as they are all ſoluble in water, and becauſe the alcohol diſſolves at the ſame time the ſaponaceous extract and a part of the ſalt. Fourcroy has therefore given a different proceſs.

Thouvenel found, from his experiments upon different ſorts of fleſh, that,

Fleſh of the ox.

1ſt. The *fleſh* of the *ox* contained about three times it's weight of water and $\frac{1}{6}$ of dry extract, which on deducting the water, gives a proportion of one to four between the extractive matter and parenchymatous ſpunge; but for this concluſion it is neceſſary to exhauſt the fleſh by repeated decoctions, for in the ordinary preparations of this kind, ſcarcely the half of this product is obtained, ſince water diſſolves a leſs quantity of the mucous matter of the parenchyma; ſo that one pound of fleſh boiled four or five hours in twelve ounces of water affords commonly five or ſix drachms of dry reſiduum, *i. e.* dried as much as poſſible by a heat that is gentle and incapable of changing it's texture.

Calf.

2d. The fleſh of the *calf* is more aqueous and mucous than that of the ox. The large quantity of reſidue from it's evaporated decoction ariſes principally from it's parenchyma being more ſoluble in water. It is the ſame in all young animals. The chicken gives more extract than the cock. They alſo give more than the ox and calf. But this ariſes in part from the bones of the firſt being admitted into theſe decoctions, as it is well known theſe ſubſtances give up to water a larger quantity of mucous matter than the fibrous part; thus ſtag's horn gives more than one fourth of it's weight; bone of the ox ſomewhat leſs, being older, more compact, and charged with oſſeous earth.

Turtle. 3d. The *land* and *water* turtles contain a little more matter ſoluble in water than the fleſh of the ox or calf, but this ariſes from the oſſeous, cartilaginous, and ligamentous parts forming a part in the common preparation of boiled turtles; hence, Thouvenel found that one pound of turtle uſed in the common way, and exhauſted by repeated decoctions, afforded more than ten drachms of reſidue, whilſt the pure fleſh gave ſcarcely one ounce in the pound; but the decoction placed on the baln. mar. for four hours, as is commonly done, gives a ſtill leſs product; ſo that eight ounces of turtle in 20 ounces of water afforded 24 ounces of broth, and the grounds being expreſſed, half an ounce of dry extract was got by evaporation. Hence common broths from turtle only contain two drachms of mucous reſidue, whilſt thoſe from veal, chicken, and mutton, contain at leaſt from five to ſix drachms.

Snail. 4th. *Snails*, ſeparated from their ſhell by means of warm water, afford on decoction with an equal quantity of water on a baln. mar. about two drachms of extract leſs in the pound than the turtle, which places them nearly in the proportion of the before mentioned fleſh, or between the ox and calf, with reſpect to the quantity of ſoluble matter.

Frogs, &c. 5. *Frogs*, *crawfiſh*, and *vipers*, deprived of their envelops, inteſtines, and extremities, and then chopped, afford, on being exhauſted by decoction, nearly the ſame quantity of extractive matter as the other animals; *i. e.* about $\frac{1}{6}$ of their weight. But this proportion is not the ſame in the common preparation of theſe broths, for theſe laſt only then afford 4 or $4\frac{1}{2}$ drachms of reſidue per pound.

Fiſh.

6th. The texture of *fiſh* being in general more tender and leſs fibrous than that of land animals, they ought to afford by decoction a greater quantity of ſoluble matter than the ſecond. Experience, however, proves the contrary, at leaſt with reſpect to freſh water fiſh, thoſe of ſalt water affording more. This difference, according to Thouvenel, ariſes principally from the more or leſs glairy ſtate, and the more or leſs concreſcibility of the mucus of all aquatic animals, which cauſes their parenchyma to be more difficultly exhauſted on decoction, and the extract more difficult to exſiccate, being more glutinous and gluey; and laſtly, this dried glue to be more inſoluble in water.

Such is the manner in which Thouvenel has examined the muſcular ſubſtance of different animals, a memoir of which got the prize of the Academy of Bordeaux in 1778.

Fourcroy's experiments and obſervations.

The proceſs, which according to Fourcroy ſucceeds the beſt, is firſt to waſh the fleſh in cold water, which takes away the colouring part with a portion of the ſalt; then to digeſt the reſiduum of this lotion in alcohol, which diſſolves the extractive matter and a portion of the ſalt; afterward, the fleſh thus treated is to be boiled in water, which diſſolves the gelatinous part and takes up, likewiſe, the portions of extract and of ſalt that had eſcaped the action of the former menſtrua. The firſt water which was employed cold, is then to be gently evaporated, the albuminous part coagulates and is ſeparated by the filter, and the ſlow evaporation of the filtered liquor affords the ſaline matter. By evaporating the alcohol in the ſame manner, the colouring extractive matter is obtained; and the decoction furniſhes the jelly and the fat oil which ſwims upon it's ſurface, and becomes concrete on cooling. After the extraction of the different ſubſtances, there remains nothing but the fibrous part, which is white, inſipid, and inſoluble in water; on burning it contracts; affords much ammonia, and a very fetid oil by diſtillation; and a large quantity of azot gas is expelled from it by the nitric acid; hence, it has all the characters of the fibrous part of the blood or of fibrin. To have a perfect knowledge, therefore, of the nature of the fleſh of animals, it only remains to examine the properties of each of the ſubſtances of which it is compoſed.

The albuminous part is ſimilar to that of the blood, and it is this matter which, on coagulating by the heat of the water in which meat is boiled, produces the ſcum which is carefully taken off. This ſcum is of a dirty brown red colour, the red being changed by the heat of ebullition. The gelatin which is extracted is the cauſe of the fleſh of young animals, after having been boiled and become cool, taking the form of a tremulous maſs or jelly, as it contains a larger proportion of this principle than the fleſh of old animals; it is common gelatin. The oil which forms itſelf into flat and circular drops, ſwims upon the ſurface of boiled meat ſoups, and becomes ſolid or concrete on cooling, is ſimilar to other animal oils. Theſe three parts are conſequently well known, and there only remains to examine the extractive matter, and the ſalts which are alſo obtained in the analyſis of the muſcles.

The ſubſtance called by Thouvenel *mucous extractive matter*, is ſoluble in water and in alcohol, it has an evident ſavour which jelly has not. In a concentrated ſtate it has an acid and bitter taſte, and a peculiar aromatic odour which the fire develops; it is this matter that colours broths and gives them their agreeable ſavour and odour. When they are too much evaporated, or a large quantity of meat is boiled in a ſmall quantity of water, it is this that gives them their more or leſs ſtrong and ſomewhat acrid taſte and deep colour; laſtly, the action of the fire extricates and heightens the ſavour of this extractive matter even ſo as to give it the taſte of ſugar or barley ſugar, as is obſerved on the ſurface of roaſt meat, which is commonly called the *brown.* If the properties of this extractive matter be examined when evaporated to a dry conſiſtence, it's ſavour is found auſtere, bitter, and ſaline; placed on a live coal, it ſwells and liquifies, exhaling a penetrating acid odour, reſembling that of burnt ſugar; expoſed to the air it becomes deliqueſcent, and a ſaline efflorèſcence takes place on it's ſurface; it becomes ſour, and putrefies on expoſure to a warm air, if diluted with a certain quantity of water; and laſtly, it is ſoluble in alcohol. All theſe characters appear to Fourcroy to prove, that this ſubſtance has a near relation to the ſoapy extracts and the ſaccharine matter of vegetables.

Since this chemiſt gave his opinion of the nature of this ſubſtance, Berthollet has diſcovered a peculiar acid in animal ſubſtances, which appears to form the characters of the matter in queſtion, for according to Berthollet, this acid which he calls the zoonic acid, (*vide* acids) has an odour which reſembles that of fleſh whilſt roaſting, and it has an auſtere taſte.

As to the ſalt which cryſtallizes during the ſlow evaporation of the decoction of fleſh, it's nature at preſent is but imperfectly underſtood.

Thouvenel obtained it in the form of down or of deformed cryſtals. He took it to be a neutral ſalt formed of potaſh, and an acid reſembling the phoſphoric acid in frugivorous quadrupeds, and muriatic acid in carnivorous reptiles. Although this ſalt may be looked upon as unknown until further examined, Fourcroy thinks it very probable that it is the phoſphat of ſoda and ammonia, and that there is even a mixture of phoſphat of lime, as theſe ſalts are indicated, and even with an exceſs of acid, as is the caſe in urine, by means of lime water and ammonia, which form white precipitates on being added to broths, and by the nitric ſolution of mercury, which produces a roſe coloured precipitate.

To theſe parts may be added that which is the moſt abundant in muſcular fleſh, and which conſtitutes it's real character, viz. the fibrous part, the characters of which are: 1ſt, to be inſoluble in water; 2d, to afford more azot gas by the nitric acid than any other ſubſtance, and to give afterward the oxalic and malic acids; 3d, to putrefy eaſily when moiſtened, and afford on diſtillation a large quantity of carbonat of ammonia. It is the ſame as that of the blood. From this fact, Fourcroy is of opinion, that the muſcular organ is the reſervoir in which the action of the vital powers depoſits the fibrous matter of the blood, which, as before obſerved, contains it in large quantity, and that by repoſe it there becomes concrete, forming the baſis of that animal property called muſcular irritability.

Fourcroy obtained, on diſtilling four ounces of ox and calf's fleſh on the baln. mar.

	Ox fleſh.			Calf's fleſh.		
	oz.	drs.	grs.	oz.	drs.	grs.
Of fluid	2	6	36	2	6	54
Dry reſiduum	1	1	36	1	1	28
	4	0	0	4	0	0

	Ox fleſh.			Calf's fleſh.		
	oz.	drs.	grs.	oz.	grs.	drs.
Another portion gave out of watery extract. (a.)	0	1	56	0	2	30
A fluid tranſmitted in b. m.	2	6	36	2	6	54
Remaining phlegm	0	1	16	0	0	52
dry fibres (b.)	0	6	36	0	5	62
	4	0	0	4	0	0
(a.) Chemically examined gave of ſal. volat.	0	1	2	0	1	12
Oil and ſpirit	0	0	38			
Carbon	0	0	6	0	1	0
Left	0	0	10	0	0	18
	0	1	56	0	2	30
(b.) Gave out of ſal volat.	0	2	0	0	0	64
Spirit volat.	0	0	36	0	1	37
Carbon	0	1	40	0	2	18
Left	0	2	12	0	0	13
	0	6	36	0	5	12

Hatchett's experiments on beef.

Some experiments on the muſcular fibre have been made by Hatchett, particularly upon that of *beef*. In order to ſeparate the liquid albuminous part, or lymph, as much as poſſible, a quantity of lean muſcle of ox beef was cut into ſmall thin pieces, then macerated during fifteen days in cold water, and afterward ſubjected to preſſure each day, when the water was changed. The weather was very cold, and the maceration continued to the end of the 15th day without any ſign of putreſcency.

The ſhreds of muſcle (amounting to about three pounds) were then boiled with about ſix quarts of water, during five hours; and the water being changed, the ſame was repeated every day during the courſe of three weeks; at the end of which, the water afforded only ſlight ſigns of gelatin, when infuſion of oak bark, or nitro-muriat of tin was added. After this, the fibrous part was well preſſed and dried by the heat of a water bath.

Some of the muſcular fibre thus prepared was ſteeped in nitric acid, diluted with three meaſures of water during fifteen days. The acid acquired a yellow tinge, and poſſeſſed all the properties of the nitric ſolutions of albumen.

The fibre which had been thus ſteeped in the acid was (when waſhed) diſſolved by boiling water, and by evaporation became a gelatinous maſs; which being again diſſolved in boiling water, was precipitated by infuſion of oak bark, and more ſlowly by nitro-muriat of tin, like albuminous ſubſtances when treated in a ſimilar manner. When the fibre which had been ſteeped in the acid was immerſed in ammonia, it was not completely diſſolved, but afforded a reſiduum. The greater part, however, was diſſolved, and formed a deep orange or yellowiſh brown ſolution, ſimilar in properties to that of albumen. (*vide* white of egg.) When boiled with lixivium of cauſtic potaſh, this muſcular fibre was completely diſſolved, ammonia was diſcharged, and animal ſoap formed; which being diluted with water, and ſaturated with muriatic acid, yielded a precipitate ſimilar to that obtained from animal ſoap, except that it ſooner became hard and ſoapy when expoſed to the air.

Muſcular fibre prepared by long maceration, and ſubſequent boiling, with frequent change of water, ſo as to be nearly deprived of all it's gelatinous part, is not eaſily brought into the putrid ſtate. A ſmall quantity was kept moiſtened with water during April, in the courſe of which time it acquired a muſty but not a putrid ſmell, neither were the fibres reduced to a pulpy maſs; a portion of it was kept two months under water, but it neither became putrid nor was converted into that fatty ſubſtance obtained from recent muſcle. Hence Hatchett is of opinion, that the readineſs with which muſcle becomes putrid is principally owing to the gelatin, which is mixed with it in large proportion, and which, with the natural quantity of moiſture, is requiſite to give the fibre a proper degree of toughneſs and flexibility.

The reſiduum afforded by muſcular fibre which had been long ſteeped in dilute nitric acid, and afterward immerſed in ammonia, conſiſted principally of fat, mixed with a ſmall portion of the fibre which had not been ſufficiently acted upon by the acid, and little or no earthy matter was thus obtained. But when the prepared muſcular fibre was diſſolved in boiling nitric acid, a complete ſolution reſembling that of albumen in it's general properties was formed, and ſome fat floated in drops at the top of the liquor. Ammonia was then added, ſo as to ſuperſaturate the acid, and produced the ſame effects as on the nitric ſolutions of albumen, excepting that a copious white precipitate was obtained. This precipitate, while moiſt, was agitated with a quantity of acetous acid, which diſſolved and ſeparated a ſmall portion of phoſphat of lime; but the remainder, and by much the greateſt part of this precipitate was ſcarcely attacked, even when the acid was boiled.

When expoſed to a red heat, it became dark gray, and then nearly white; after which it was in the ſtate of carbonat of lime.

Another part was diſſolved in nitric acid, and lime was precipitated by carbonat of ſoda. The ſlight exceſs of the latter was then ſaturated by acetous acid, and the whole was boiled to expel the carbonic acid; after which the liquor from it's effects on ſolutions of lime, barytes, &c. evidently contained oxalic acid in ſolution; the precipitate was therefore oxalat of lime mixed with a very ſmall quantity of phoſphat of lime; 200 grains of the dry muſcular fibre, diſſolved and boiled with nitric acid, afforded 17 grains of this precipitate.

Although it is known that the gelatinous liquor obtained from muſcle by boiling water, contains phoſphats of ſoda and of lime; yet Hatchett did not imagine the greater part of the latter could be ſo completely ſeparated. He, therefore, in ſome meaſure, repeated the experiment on

Veal.

the *muſcle of veal*, and found phoſphats of ſoda and of lime in the liquor. But when the muſcle was afterward diſſolved in boiling nitric acid, and the ſolution ſaturated with ammonia; he was ſurpriſed to find that although the ſame change in colour was produced as in all the former experiments, the liquor remained tranſparent, and even after ſeveral days, only a few ſcattered particles appeared at the bottom of the veſſel.

Mutton.

Another experiment was made on the recent muſcle of *mutton*, but this was immediately diſſolved in nitric acid, without being previouſly boiled in water. The fat being ſeparated, the ſolution was as before ſaturated with ammonia, and as uſual became of a deep orange colour, or yellowiſh brown; in a few hours alſo, a ſmall quantity of a white precipitate ſubſided. This precipitate, however, was completely and readily ſoluble in acetous acid, and in every reſpect proved to be phoſphat of lime.

This chemiſt obſerves, that the liquor from which the above precipitate was ſeparated, as well as thoſe afforded by the muſcle of veal, by the prepared muſcle of beef (as well as by the ſolutions of tortoiſeſhell and albumen) in boiling nitric acid, ſubſequently ſaturated with ammonia, all contained a conſiderable portion of uncombined oxalic acid, which was ſeparated by acetite of lime and of lead. But he did not find oxalic acid in the ſolutions formed by immerſing the bodies, for a long time, in cold and dilute nitric acid; neither did he find oxalic acid in ſolutions made by diſſolving the ſubſtances in boiling muriatic acid. It is evident, therefore, that the oxalic acid obſerved in the above experiments was a product of the operations, and not an educt of the ſubſtances.

His concluſions.

Hatchett concludes from the experiments upon the above muſcular ſubſtances, that they contain lime in various proportions, and in two different ſtates, viz. carbonat and phoſphat, and that the greater part of the latter is gradually ſeparated, in conjunction with the gelatin, by means of boiling water. Not that phoſphat of lime is an eſſential ingredient in gelatinous ſubſtances, on the contrary, iſinglaſs, which is a perfectly gelatinous body, affords but a mere viſible trace of it. The muſcular fibre of beef appears to have been nearly deprived of it's phoſphat of lime, by the long-continued and repeated boiling in water to which it had been ſubjected; but ſtill ſo large a quantity of lime remained, that when oxalic acid was formed by the action of the boiling nitric acid, it combined with the lime and formed an oxalat amounting to 19 grains from 200 grains of the dry muſcular fibre, diſſolved in nitric acid, and precipitated by ammonia. He does not know what quantity of lime was ſeparated with the gelatin; but from the quantity of lime remaining, and which afterward combined with the oxalic acid, the muſcle of beef muſt contain a conſiderable portion of earthy matter; and as by the experiment on the muſcle of veal, ſcarcely any precipitate was obtained after it had been boiled, and as but a ſmall portion of phoſphat of lime was preſent in the gelatinous liquid, it appears, that in this muſcle, the whole of the ſmall portion of lime it contained was in the ſtate of phoſphat; and this being nearly ſeparated, there did not remain any part of uncombined lime or carbonat of lime, which by uniting with the oxalic acid (ſubſequently produced) would form an oxalat; and as lime in the ſtates of phoſphat and carbonat is ſo much more abundant in the muſcle of beef than in that of veal, it may be inferred that the earthy matter is more abundant in the coarſe and rigid fibre of adult and aged animals, than in the tender fibre of young ones; and this ſeems to be corroborated by the tendency to morbid oſſification, ſo frequently obſerved in aged individuals of the human ſpecies. Five hundred grains of the dry prepared muſcular fibre of beef, when diſtilled, left 108 grains of coal, which, by incineration, afforded 25,60 grains of earthy reſiduum; the coal may therefore be eſtimated at 82,40 grains. The greateſt part of theſe 25,60 grains was carbonat of lime mixed with ſome pure lime and a ſmall portion of phoſphat, and there can be no doubt but that the latter would have been more abundant, had it not been for the repeated boilings to which the muſcular fibre had been ſubjected.

The recent muſcles of veal and mutton were, with great difficulty, reduced to aſhes; for toward the end of the proceſs, the aſhes and remaining coal became coated and glazed with ſaline matter, which appeared to be ſoda, partly in the ſtate of phoſphat.

Component parts of fleſh.

It appears, therefore, from the experiments already mentioned, that muſcle or fleſh conſiſts of albumen, gelatin, fibrin, the phoſphats of ſoda and of lime, muriat of ſoda, the zoonic acid, and iron; but a more exact analyſis is neceſſary to aſcertain it's component parts with preciſion and certainty.

LIVER.

Liver of the ſkate examined by Vauquelin.

The human liver has been examined by Fourcroy, but it was in a ſtate of decompoſition or putrefaction. Vauquelin, who has already rendered himſelf ſo highly eminent in the analyſis of animal ſubſtances, has given a detailed account of that of the liver of the ſkate.

It is well known to anatomiſts, that the liver of this fiſh (raya batis, L.) is very voluminous when compared to the other viſcera, ſuch as the heart and lungs, that it's ſtructure and texture are very delicate and tender, and that externally it's appearance is fatty and oleaginous. It is of a gray cólour, and when freſh has a roſy tinge, but this varies in different livers. It's ſavour is ſaline and oily ; it's odour reſembles that of mud, and is ſomewhat analogous to what ariſes from the filth of fiſh-markets. When boiled in water, it produces a great quantity of oil, which remains fluid at the ordinary temperature of the atmoſphere. A piece of this liver produced by expreſſion, after boiling, a ſlightly yellow coloured oil, that remained liquid at 10°.—When triturated with cold water in a mortar, it formed a white emulſion reſembling milk, and in a few hours Vauquelin obſerved, that a yellowiſh cream aroſe to the ſurface, which appears to have been a portion of oil with a ſmall part of the parenchyma. This emulſion was decompoſed by the weakeſt acids, and ſmall grumous parts ſeparated from the clear liquor and aroſe to the top, as takes place in the decompoſition of ſoaps by acids. This cream, on being agitated ſome time in a marble mortar, afforded no butter, but an oil much thinner than that extracted by heat. The parenchymatous and albuminous parts, which were coagulated, became brown in the air. The ſolution changed paper coloured by mallows to a green, which this chemiſt attributes to an incipient putrefaction. Four ounces of this liquor bruiſed, and expoſed to a gentle heat till no more vapours aroſe, afforded by expreſſion one drachm ſeven grains of oil, the remainder weighed four drachms thirty-ſix grains; this laſt quantity of parenchyma, when incinerated, gave eight grains of a ſemifuſed white matter, which adhered ſlightly to the ſides of the crucible. On adding muriatic acid to this matter, a ſulphureous vapour was diſengaged, and the liquor ſoon changed to a ſlight yellow colour, but there was no efferveſcence on the addition of lime-water; it appeared from the precipitation, that the aſhes contained phoſphat of lime.

Oxygenated muriatic acid being poured upon two drachms of this oil, until it ceaſed to give an odour, *i. e.* until ſaturated with oxygen and not decompoſed, the oil became white as fat, and of the conſiſtence of wax that has been kept between the fingers for ſome time. Theſe experiments prove, according to this chemiſt, that the liver of the ray contains more than half it's weight of oil already formed, and as to the concluſion to be drawn from it, *vide* article Bile.

Elémens d'Hiſtoire Naturelle et de Chemie, 4. edit. par M. Fourcroy. t. 4. p. 431. 1791.—Encyc. Méth. Méd. t. 4. p. 573. chair des animaux.—Examen Chimique du Foie de Raie, par M. Vauquelin. An. de Ch. tom. 10. p. 193.—Hatchett's Expts. Phil. Tranſ. 1800.

WHITE PARTS.

BRAIN.

THE opinions with reſpect to the compoſition of this organ have been chiefly confined to it's ſuppoſed oily nature, whilſt others have denied it to poſſeſs any ſuch property. Plato compared the brain to marrow, becauſe like that ſubſtance it is ſoft and encloſed in an oſſeous envelop. Hippocrates, on the contrary, would not allow it to contain any thing that reſembled fat. Ariſtotle was of opinion, that it was of a fatty nature in man and quadrupeds, and in the cetaceous claſs he had no doubt of it. This was again denied by more modern writers, and again aſſerted by Bartholin and Diemerbroeck; and as a proof in it's favour, they announced it's fatty touch, and it's inclination to liquefy or melt rather than run. Lewenhoeck, on examining the cortical part of the brain of a bird, thought it was formed of ſmall veſſels, and of a ſpecies of vitreous humour ſimilar to fat. Afterward, chemical analyſis came to ſupport that opinion, and Lemery in particular, on ſubmitting the brain to diſtillation, obtained a large quantity of limpid phlegm, volatile alkali, and two kinds of oil; the one yellow, and of the conſiſtence of butter; the other black, fetid, and as thick as pitch. Burrhus alſo examined it, and on ſubmitting it to the action of a hot preſs, after having ſqueezed out about three-fourths of it's weight of an inodorous phlegm, extracted a very inflammable oil from it, which on cooling ſuddenly, took a concrete form. Thouret has ſince made ſome experiments on this organ; for although it was known to poſſeſs oily properties, not only from

Brain.

Ancient opinions.

what has been already mentioned, but from it's having been found perfectly preſerved for even fifty or eighty years from putrefaction, appearing like a fat or oily fluid matter, as we are informed by Faber and Herbinius; and although the ſolubility of the brain in aqueous fluids was known to anatomiſts, yet it's ſoapy character, or that it's oil was rendered miſcible with water by means of an alkaline ſubſtance, was not even conjectured, until the experiments of this chemiſt pointed it out. It is from

Examined by Thouret.

theſe Thouret concludes that the ſubſtance of the brain reſembles that of the ſingular ſpecies of ſoap into which the greater part of the bodies was found to be transformed in the cemetery of the Innocents at Paris. It is like this laſt, formed of a more or leſs concrete and cryſtallized oily matter, very fuſible, ſoluble in ſpirit of wine, and forming a ſpecies of real ſoap; and the only difference between them is, that in the bodies of the Innocents the oil is united with volatile alkali, whilſt in the brain, potaſh is the alkaline ſubſtance; and he concludes, that it is from this oily or ſoapy nature, which appears to reſemble ſpermaceti, that this organ is found to be ſo little ſuſceptible of decompoſition in the earth, provided it does not meet with any great degree of humidity, and that it is enabled to exiſt ſo long after all the other ſoft parts of the body are entirely decayed.

Fourcroy.

The experiments of Fourcroy appear to lead to a concluſion very different from thoſe of the laſt mentioned chemiſt, they were made upon the freſh brains of the calf, the ſheep, and the human animal, deprived of their ſanguiferous veſſels and membranes, interpoſed between the circumvolutions. Theſe brains on being left to themſelves for ſeveral days, at a temperature of twelve degrees, exhaled a very diſagreeable odour, and ſenſibly changed blue paper green; and this before the production of any ammonia, although the green colour and deteſtable odour would ſeem to indicate an alkaleſcency. It partakes of this property with all other animal ſubſtances that contain mucilage, gelatin, or any white fibres ſuſceptible of paſſing into the ſame ſtate by the action of heat. Some dried brain, on being boiled with alcohol, formed a ſort of glutinous paſte, of a deep colour, ductile, and when preſſed by the fingers, capable of being lengthened all ways. It does not melt in the heat of boiling water, but only becomes ſofter; when expoſed to a higher temperature, it appears inclined to liquefy, it's colour becomes deeper, and of a darkiſh yellow; there ariſes an empyreumatic ammoniacal ſmoke, and the heat is increaſed; there remaining only a coal.

Fourcroy obſerves, that it is this ſubſtance that Thouret has not heſitated to compare to ſpermaceti, to the adipocerous matter of the bodies of the Innocents, and to the concrete oil extracted from biliary calculi by alcohol. Theſe three ſubſtances have, however, no ſimilarity with it in the eyes of the experienced chemiſt; for it is well known that a degree of heat from 30° to 32°, is ſufficient to melt ſpermaceti and the adipocerous ſubſtance. As to the concrete biliary matter, it requires ſome degrees above boiling water to become fluid, and it does not emit during it's paſſage to that ſtate any empyreumatic or ammoniacal vapour like that of the brain. Theſe matters this chemiſt contends have therefore no reſemblance, except a tendency to take a regular form on becoming fixed, and he looks upon this matter to be a ſubſtance *ſui generis*, which differs from all other animal ſubſtances in the proportions of it's principles. Thouret relates, that Burrhus had expreſſed an oil from dried brain, concreſcible by cold, which he compared to ſpermaceti; but Fourcroy is of opinion, that by the ordinary means employed to extract oils and fats, contained naturally in animal as well as vegetable ſubſtances, it is not to be got from the brain, and that it is only by changing it's principles that ſome chemiſts have been able to obtain it. Compoſition of the brain. From the analyſis of this organ, Fourcroy concludes, that beſides this animal pulp *ſui generis*, the brain is compoſed of the phoſphats of ammonia, of lime, and of ſoda; that each is only in ſmall proportion, that it contains no free alkali, and not an atom of potaſh, although admitted to exiſt in it by Thouret, and that of all animal ſubſtances the brain approaches the moſt in it's nature to that of the albumen of the blood.

Mémoire ſur la Nature de la Subſtance du Cerveau, &c. par M. Thouret. Journal de Phyſique. Mai. p. 329. 1791.—Examen Chimique du Cerveau de pluſieurs animaux, par A. F. Fourcroy, Annales de Chimie. tom. 16. p. 282.

SKIN.

Of the ſkins or hides of animals, there has only been a ſlight examination of the epidermis of the human ſkin. According to Chaptal, the human epidermis is the moſt eaſily detached from the cutis of any, and it may be effected by the heat of water. The cutis then reſembles ſoftened cartilage in conſiſtence. On continuing the boiling the ſkin is diſſolved, but the hot water has no action on the epidermis. Skin. Examined by Chaptal.

Dilute nitric acid, according to Hatchett, has the ſame effect.

The epidermis is ſoluble in cauſtic alkalis; and by lime, although more ſlowly.

Alcohol digeſted a long time upon it with heat produced no effect.

From theſe circumſtances Chaptal concludes, that there is ſome analogy between the exterior envelop of the human body, and that which acts as a cover to ſilk; and he draws ſome conſequences that may be applied to the operations of tanning, thus:

1ſt, If a hide covered with it's epidermis be plunged into an infuſion of tan, this laſt can only penetrate by the fleſhy ſide, the other being defended from it by the epidermis which is not ſuſceptible of any combination with the tanning principle.

2d. When the epidermis has been taken off by the operation of depriving it of the hair, the tan is able to penetrate by both ſurfaces of the ſkin.

3d, The lime generally employed to take off the hair appears to act only by diſſolving the epidermis. He found lime-water to have a ſtronger action than lime undiſſolved, but that it's effect ceaſed the moment the ſmall quantity of lime held in ſolution became combined; hence, the neceſſity of renewing the lime-water to finiſh the operation.

Seguin on tanning.

For the diſcovery of the true principles upon which the art of tanning hides is founded, we are indebted to Seguin. Before the inveſtigation of this chemiſt, it was generally ſuppoſed that the tan in the tan pits had no other effect on the hides, than to harden and brace the fibres of the ſkin which had been relaxed by the preliminary operations; but the experiments of Seguin prove, that there exiſts in the tan a principle that is ſoluble in water, by which the tanning is effected; that this principle becomes afterward fixed in the hide in conſequence of a particular combination between this principle and the ſkin, and that this combination produces a ſubſtance inſoluble in water.

It is well known that if untanned leather be boiled in water it is ſoon diſſolved by it, and this ſolution by being concentrated produces a jelly or ſize, which, by further evaporation and exſiccation in the air, becomes what is called glue.

Explanation of the proceſs.

On examining the effect of a ſolution of tan upon a ſolution of glue, they are ſcarcely mixed before a white filamentous precipitate takes place, ariſing from the union of the gelatin with the tanning principle. This precipitate is inſoluble both in hot and cold water, and acquires colour on expoſure to light. This is the real explanation of the proceſs of tanning. The ſolution of tan therefore acts upon the hides (from which glue is produced) in the ſame manner as it acts upon glue, and is what happens both in common tan pits and in the new method of tanning by Seguin, in both of which the ſolution of tan gradually penetrates the hide and combines with it, producing a gradual change of colour till the hide is changed throughout, becoming of a marbled appearance reſembling a nutmeg, and of a compact texture. From this it appears, that a precipitation alſo takes place in the action of tanning, although the hide is not diſſolved, but merely ſwelled, ſo as to enable the ſolution of tan to penetrate it more eaſily.

This property which animal glue or gelatin has of being precipitated by a ſolution of the tanning principle, affords a method of diſcovering what ſubſtances may be uſeful in tanning. Nothing more is neceſſary than to make a ſolution or infuſion of the vegetable ſubſtance, and this when mixed with a ſolution of glue will ſhow whether it can be employed with advantage in tanning, by the greater or leſs quantity of precipitate produced.

Lime-water, likewiſe, according to the ſame chemiſt, offers an excellent means of diſcovering ſuch ſubſtances. If, for inſtance, lime-water be added to a ſolution of tan, the mixture inſtantly produces a copious precipitate; and if a ſufficient quantity of lime-water be added to neutralize the whole quantity of the tanning principle, the ſupernatant liquor, ſtill coloured, will not form any precipitate with a ſolution of glue. In like manner, the liquor ſeparated from a precipitation by the mixture of a ſolution of tan with one of glue, will not produce any precipitate with lime-water, if during the precipitation the tanning principle has been completely neutralized. This ſhows that Macbride's method of extracting tan by means of lime-water is defective; and that a loſs of the tanning principle, takes place, in proportion to the quantity of it combined with the lime diſſolved in the lime-water.

From the preceding account of the action of glue or of lime water upon a ſolution of tan, it follows, that every vegetable infuſion, which affords a precipitate upon the addition of either of theſe reagents, muſt contain in a greater or leſs proportion the tanning principle. A decoction of Peruvian bark, for inſtance, when mixed with lime-water, gives a precipitate which ariſes from the union of the lime and the tanning principle of the bark.

Tanning matter.

The tanning principle appears to be a ſubſtance of a peculiar nature, which exiſts in aſtringent vegetables, and is not, as has been ſuppoſed, that acid called the gallic acid diſcovered by Scheele in galls, and found likewiſe in aſtringent vegetables, and ſaid to have ſome effect in tanning. To the diſcovery of this tanning matter which Seguin found to be ſoluble in water, and which by uniting with the gelatin of the ſkin renders it an inſoluble compound; it may be added, that when the water has extracted all the tanning matter from the tan, even to ſaturation, and has given it up to the gelatin of the hide; the ſame water may be uſed to extract more of the ſame matter from freſh tan; this facilitates the carriage of the tanning matter by reducing it to a ſmall volume, or it may be converted into an extract. According to Prouſt, the aqueous ſolution of tan poured on a ſolution of glue, produces a magma poſſeſſing the elaſtic properties of the gluten of flour; that when left to itſelf it contracts, and on perfect exſiccation is brown and reſembles glaſs in it's fracture; that it is incapable of putrefaction; perfectly ſoluble in water; yields very little to alcohol, and by the means of hot water is capable of recovering it's elaſtic properties. He likewiſe found, that the tanning liquor cauſes a precipitation in albuminous fluids, but the reſult is not a magma capable of the ſame tranſaction. Berthollet ſuſpects that tanning cannot take place without the action of air, *i. e.* in cloſed veſſels.

Having given ſome account of the principles upon which the art of tanning is founded, it will not be deviating from the ſubject to add a ſhort deſcription of the new chemical proceſſes, which have been formed to accelerate the preparation of the ſkins, and the combination of the tanning matter or principle.

Previous to the experiments of Seguin, the proceſs of tanning was an operation of much time and trouble, even years were neceſſary to bring the hide to a ſtate of leather. The revolution this chemiſt has brought about in this art enables the tanner to complete his formerly arduous proceſs in the ſhort ſpace of a few days, whilſt the leather is ſuperior in quality to that made after the old method.

New method of tanning according to Seguin.

The operations of this chemiſt conſiſt, as in the former proceſs of tanning, viz. in waſhing the hides, depriving them of the fleſh and hair, raiſing or ſwelling them, and tanning properly ſo called; but the modifications and alterations he has made in theſe proceſſes are very different. To this may be added that he operated upon 110 hides of oxen, cows, calves, horſes, ſheep, and goats, in the preſence of Lelievre and Pelletier.

1ſt. *Waſhing and cleanſing the hides.* In this operation no alteration is made by Seguin; he does not however throw them promiſcuouſly into water as ſome tanners do, but ſtretches or extends them ſo as to permit the water to come into contact with every part. This precaution had already been recommended by others.

2d. *Taking off the hair.* With reſpect to ſhaving it off, which has always been looked upon as the moſt expeditious way, from ſome trials it was found by Seguin to be attended with diſadvantages. Hides, it is well known, are covered with an epidermis, which is deſtroyed by the method of depriving them of their hair by lime; but as it ſtill remains after the proceſs of ſhaving, it is a great obſtacle to the action of the tanning matter, by preventing it's ſolution from penetrating the hide on it's grain ſide; hence, a longer time is required for the proceſs of tanning.

With reſpect to the employment of alkalis in taking it off, they are too expenſive for common practice.

With reſpect to the method by means of lime, we are informed that ſome lime was firſt ſlacked; it was then put into a pit and mixed with a large proportion of water, and the whole was well ſtirred that the water might be well ſaturated with the lime; the hides were then ſuſpended perpendicularly in the lime-water by ſtrings attached to poles laid acroſs the pit, and as it loſt it's ſtrength, the lime at the bottom was often ſtirred in order to keep the water ſtill ſaturated. The hair came off with great eaſe in this operation, after remaining about eight days in the pit.

By another method this chemiſt is in hopes of taking off the hair in two days. This conſiſts in plunging the hides after being waſhed and cleanſed in old tan water (which having been already uſed contains no tanning matter) mixed with a $\frac{5}{100}$ part, or ſometimes with only $\frac{1}{1000}$ part of ſulphuric acid. He found that pieces of hides thus treated were deprived of their hair with great eaſe, and very completely raiſed or ſwelled. This chemiſt has ſo much confidence in this proceſs, that he informed Lelievre and Pelletier, in whoſe preſence it was performed, he would adopt it in a tan yard in preference to any other.

He is likewiſe of opinion that another method of taking off the hair might be advantageouſly practiſed in a tan yard, viz. by heat, produced by a ſtove kept conſtantly at 30° of Reaumur in which the hides are to be ſuſpended; and it is obſerved by the above mentioned gentlemen, that if a little ſulphur was burnt in the ſtove, ſo that the ſulphureous acid gas ariſing might be equally diffuſed, it would greatly facilitate the proceſs.

3d. *Swelling or raiſing the hides.* For this purpoſe large wooden tubs well joined together are filled with water, and a $\frac{15}{100}$ part of ſulphuric acid added; into this mixture the hides are put, after having been previouſly well waſhed and deprived of their hair. This quantity was decreaſed to $\frac{1}{1000}$. The hides began to ſwell after having remained a ſhort time in this liquor, and in 48 hours the ſwelling is completed. They now acquire a yellow colour even in the interior part of their ſubſtance. In this ſtate, according to Seguin, the proceſs of ſwelling is finiſhed: to determine this, one of the corners of the hide is to be cut, and if it be in a proper ſtate, no white ſtreak will appear in the middle; but through it's whole ſubſtance the hide will have acquired a yellow colour, and a ſemi-tranſparent appearance. This method, it may be obſerved, is the ſame as that of Macbride, except that the proportion of ſulphuric acid is much diminiſhed.

According, however, to Seguin, this operation of the ſwelling of the hides may be diſpenſed with, ſince he has tanned them equally well without it; he even found the leather much leſs porous, and conſequently leſs permeable to water.

4th. *Proceſs of tanning according to Seguin.* Tanning, properly ſo called, is performed by this chemiſt, after a particular method. He does not lay the hides in a pit as is uſually practiſed, but tans them by means of a ſolution of tan which he prepares in the following manner: He places ſeveral rows of caſks upon ſtands elevated ſo much above the ground, that a veſſel may be placed under each to receive the liquor which runs from them. Theſe caſks are filled with freſh tan; a certain quantity of water is then poured into the firſt of them, which, as it runs through the tan, extracts the ſoluble part, and as faſt as it runs into the veſſel below is taken out and poured into the ſecond caſk, and ſo on ſucceſſively until the ſolution is ſufficiently ſaturated; it may be brought to 10° or 12° of the areometer for ſalts. In order to exhauſt the tan of the firſt caſks, freſh water is poured upon it till it runs off perfectly clear, as the tan is then completely deprived of it's ſoluble part. The liquors, as may be eaſily conceived, are carefully kept for future operations. It is propoſed by this chemiſt, to make uſe in a tan yard of large wooden vats, for the preparation of the ſolution of tan.

It is particularly in the uſe of this ſolution that the method of Seguin conſiſts. The quickneſs with which it acts is aſtoniſhing, and our ſurpriſe is excited that no perſon before him has attempted to put this method in practice in the large way.

As ſoon as the hides are taken out of the water impregnated with ſulphuric acid, they are to be put into a weak ſolution of tan, where they are to be left one or two hours; they are then to be plunged into other ſolutions, more or leſs charged with this principle according to their ſtrength, ſo that ſtrong hides are tanned in ſix or eight days, others in fifteen, and others in twenty or twenty-five days. In placing the hides in theſe ſolutions ſome precautions are neceſſary.

Seguin propoſes to have large vats which are to be filled with a ſolution of tan, the hides are then to be placed in them ſo as to be perpendicularly ſuſpended about one inch diſtant from each other, as their touching would impede the action of the ſolution.

The hides, when taken out of the ſolution, muſt be dried with the uſual precaution, *i. e.* ſo ſlowly as not to cauſe the hide to ſhrink on the fleſh ſide. With reſpect to thinner hides, for the upper leather of ſhoes, he begins by waſhing and taking off the fleſh in the manner deſcribed for ſtrong ſole leather; he then takes off the hair with clear lime-water; they do not undergo the operation of ſwelling, but are immediately put into weak ſolutions of tan, the ſtrength of which he gradually increaſes, but without ever being brought to that degree of concentration uſed for tanning thick leather. Two, three, or four days, are ſufficient for tanning this thinner leather.

Leather which has not been ſufficiently impregnated with the tanning matter, is generally known by a white ſtreak in the middle of it's ſubſtance. This, however, was not perceptible in the hides tanned by Seguin in the preſence of the above gentlemen. This method has likewiſe the advantage of affording an opportunity of examining from time to time the progreſs of the operation. For this purpoſe, nothing is neceſſary but to take a ſlip of the hide out of the vat, to cut off a corner of it, and the white ſtreak, already mentioned, will appear more or leſs thick, until the tanning is completed.

Advantages of the new method.

The advantages of Seguin's method are, 1ſt. *It is much ſhorter.* The common method with lime requires, for ſtrong ſole leather, a year for the preliminary operations, and ſometimes fifteen months more for the tanning operation in the pit. Sometimes it remains two years in the tan pits, it being pretended that the ſuperiority of the leather is to be attributed to the great length of time the hides are left in them, ſo that they even ſometimes remain two years and a half to carry the proceſs to the greateſt perfection. The duration of Seguin's method is only about twenty days; in winter it is longer. 2d. *It is leſs laborious.* No manual labour is required, except in taking off the fleſh and hair, for as ſoon as the hides are put into the ſolution of tan, they remain till the proceſs is completed; whilſt in the old way, there is a great deal of labour in taking them out of the pits, from time to time, to turn them. 3d. *It is leſs expenſive.* There is one thing here to be obſerved; it is better only to prepare as much tanning ſolution as is neceſſary for preſent uſe, as the above gentlemen thought they obſerved a diſpoſition in the ſolutions of tan to paſs into the vinous fermentation, which if the acetous ſhould follow before the ſolution is exhauſted, it would be an abſolute loſs of the tanning principle. Hence it is neceſſary to be watchful, eſpecially in ſummer. 4th. *It produces leather at leaſt of equal goodneſs.* To which may be added the important advantage of the extract of tan, which can be prepared in any foreſt on the ſpot, which from it's ſmall volume and weight, when compared to oak bark, may be carried away with the greateſt facility. It might be made in America, and tranſported to Europe, and alſo from other vegetables beſides the oak. When uſed, it is only neceſſary to rediſſolve it in a proper quantity of water.

Biggin's experiments to aſcertain the quantity of tan.

Since the bark of trees contains two principles, viz. the tanning, and the aſtringent, or in other words, tanning matter and the gallic acid, both of which are applied to the hide in the proceſs of converting it into leather; it remained to inveſtigate, whether or not the gallic acid was hurtful or uſeful; and for this purpoſe, Biggin made ſome experiments upon different barks, to aſcertain the quantity of tan and gallic acid each bark contained, according to the proceſs of Seguin.

His teſt to diſcover the tan, was a ſolution of one ounce of common glue in two pounds of boiling water, which conſequently contained the matter of ſkin, as he calls it, in ſolution; and for a teſt of the gallic acid, he uſed a ſaturated ſolution of ſulphat of iron.

For a preparation of bark, he divided one pound of each bark, in a pulverized ſtate, into five parts, which he put into five different earthen veſſels. To one part of this, he added two pounds of water, and infuſed them during one hour. This was then poured upon a ſecond part, and this again on the third, and ſo on to the fifth. But as a certain portion of the infuſion might remain attached to the *wood* of the bark, after decantation, he added a third pound of water to the firſt part, and then followed up the infuſion on the ſeveral parts, till the three pounds of water, or as much of them as could be ſeparated from the bark, were united in the fifth veſſel, from which he generally obtained about one pint of ſtrong infuſion of bark.

To a certain quantity of this infuſion, he added a given meaſure of the ſolution of glue, which formed an immediate precipitation, to be ſeparated by filtering paper. This, when dried, is the powder of leather, formed by an union of the matter of ſkin with the tanning principle, and, by ſaturating the infuſion, the whole of the tan may be ſeparated by precipitation.

The gallic acid.

To procure the gallic acid, he added to the pound of bark left in the earthen veſſel, already deprived of the tan by theſe *quick* infuſions, a given quantity of water; but to get a ſtrong infuſion of this acid, a longer time (for inſtance 48 hours) is required. This infuſion, when obtained pure (it being ſcarcely poſſible to ſeparate them by this means, ſince a little of the acid always remains in the infuſion of tan, and vice verſa, unleſs the infuſion of the gallic acid is very weak, and procured by a third or fourth operation) gives very little ſigns of the preſence of tan, when tried by the ſolution of glue; but with the ſolution of ſulphat of iron, a ſtrong black colour is produced which differs in denſity according to the quality of the bark; and this may be further proved by boiling a ſkain of worſted in the dye, by which the gradations of colour may be perceptibly demonſtrated.

Having thus obtained a point of compariſon, and ſtrictly attending to the ſpecific gravity of the infuſion, the quantity of precipitate of leather, and the denſity of colour produced by given quantities of one or the other teſt, the reſult will be found a comparative ſtatement of the reſpective powers of any bark or vegetable ſubſtance, which is ſufficiently accurate for all commercial purpoſes; and the quantity of tan contained in them, when compared with that in the oak bark, the uſual ſubſtance employed for the purpoſe of tanning, will determine the commercial utility of the bark.

For an accurate chemical analyſis, he found the muriat of tin very convenient; for a ſolution of it being added to the infuſion of bark, forms a precipitate with the tan, leaving the gallic acid ſuſpended. This precipitate is of a fawn colour, and is compoſed of tan and oxydated tin. By theſe means, Biggin has been enabled to form a comparative ſcale of barks, which, however, he allows to be imperfect. In the following ſcale he has taken ſumach as the moſt powerful; leaving, at the ſame time, a few degrees for a *ſuppoſed maximum of tanning principle*, which he reckons at 20.

Bark of the	Gallic acid by colour.	Tanning princ. by the hydrometer.	Tan. princ. (in grains) from half a pint of infuſion, and 1 oz. of ſolution of glue.
Elm	7	2.1	28
Oak, cut in winter	8	2.1	30
Horſe cheſnut	6	2.2	30
Beach	7	2.4	31
Willow (boughs)	8	2.4	31
Elder	4	3.0	41
Plum tree	8	4.0	58
Willow trunk	9	4.0	52
Sycamore	6	4.1	53
Birch	4	4.1	54
Cherry tree	8	4.2	59
Sallow	8	4.6	59

Mountain aſh	8	4.7	60
Poplar	9	6.0	76
Hazel	9	6.3	79
Aſh	10	6.6	82
Spaniſh cheſnut ..	10	9.0	98
Smooth oak	10	9.2	104
Oak, cut in ſpring	10	9.6	108
Huntingdon, or Leiceſter willow ...	10	10.1	109
Sumach	14	10.2	158

Biggin found that theſe barks preſerved no reſpective proportion in the quantity of gallic acid and tanning principle contained in each, which he looks upon as an evidence of the diſtinctneſs of them, and may perhaps open a new field of ſaving oak bark in dying, ſince the willow, ſallow, aſh, and others, produce a very fine black. The quantities, likewiſe, of theſe two principles, do not differ in equal proportions between the winter and ſpring felled oaks, which may lead to a diſcrimination of the proper time for cutting, which is probably when the ſap has completely filled and dilated that part of the vegetable intended for uſe. This will make a difference in the ſeaſon of cutting oak, elm, and other trees, ſhrubs, &c. The leaves ſhould be taken when at their full ſize, and then dried under cover; for as the tan is ſo ſoluble, and the ſubſtance that contains it, ſo thin, (the leaf) the dew is ſufficient to diſſolve it.

Finally, ſince the gallic acid does not ſeem to combine with the matter of ſkin, and as it's aſtringency will corrugate the ſurface, Biggin thinks it may be concluded, that it's preſence in the art of tanning is not only uſeleſs but detrimental.

Sur l'Epiderme par le Cit. Chaptal. Annal. de Ch.

No. 77. p. 221. Prouſt ſur le Principe Tannant. ibid. Mars, 1798, vol. 25, p. 228.—Account of the new Method of Tanning propoſed by Monſ. Seguin, by Meſſrs. Lelievre & Pelletier, Repertory of Arts, p. 272.—Vide alſo, Mémoire, Trouver le Moyen de rendre le Cuir impermeable à l'Eau ſans altérer ni ſa force, ni ſa ſoupleſſe, & ſans en augmenter ſenſiblement le prix. par le Cheval. de St. Real. Ann. de Chimie. tom. 10, p. 44.—Experiments to determine the quantity of tanning principle and gallic acid contained in the bark of various trees, by George Biggin, Eſq. Nich. Journal. No. 34, p. 392.

MEMBRANOUS, TENDINOUS, AND LIGAMENTOUS PARTS.

Their properties.

UNDER this head are to be comprehended all the fine membranes and cellular texture of the animal body; the white membranes that line the different cavities, as the pericardium, dura mater, pleura, &c. thoſe that cover certain parts, as the perioſteum, aponeuroſis, &c. the different tendons that are attached to the muſcles, and all others of a ſimilar nature; and the ligaments that unite the joints, together with all others of ſimilar appearance.

Theſe, when ſubmitted to chemical analyſis, appear to be all of a ſimilar nature; but they have not at preſent been examined with ſuch preciſion as to point out any minute differences that may exiſt between them, and which might appear to ariſe from the proportions of their component parts. They are inſoluble in cold water; but by a gentle heat and after a certain time, they produce an acidity, perceptible both by the ſmell and taſte. They readily paſs to the putrid fermentation; but what characterizes them moſt is, that when theſe white membranous, tendinous, and ligamentous parts are put into boiling water, or are ſubmitted to a boiling heat, they ſoon become ſoft, loſe their texture, and are converted into a viſcous, clammy, more or leſs thick liquid, which, on becoming cool, takes the form of a clear jelly, and which is of great uſe in the arts under the name of *glue*. When expoſed to a gentle heat, without the intervention of water, they become dry, loſe their toughneſs, are tranſparent, brittle, and eaſily break with a ſnapping between the fingers. By a ſtronger heat, they curl up and are contracted, and, on continuing the heat, they melt, produce a fetid diſagreeable ſmell, although not ſo empyreumatic as the more animalized parts; they ſwell and inflame, although the inflammation is ſomewhat difficult. The coal which remains, is light, and eaſily incinerated, whilſt from their affording the uſual products of animal ſubſtances in a ſmall degree, they may be looked upon as but ſlightly animalized.

GLUE.

Glue. At the article *Gelatin*, it is obſerved, that it is particularly from the white parts of animals that ſubſtance is extracted; but as it was not intended, on diſcuſſing the nature of the component parts, to make any application of them to the arts, an account of the making of glue, and other circumſtances attending it, were reſerved for the preſent.

Glue has nearly all the properties of gelatin; the difference, according to Fourcroy, conſiſting only in the conſiſtence. Gelatin has leſs viſcidity and tenacioùſneſs, being more particularly obtained from young animals; whilſt glue, on the contrary, is only obtained from old animals, whoſe fibre is become drier and more ſtrong.

Du Hamel. According to du Hamel du Monceau, who has written, perhaps, the beſt work on the ſubject; glue was firſt principally prepared from a ſolution of the membranous, tendinous, and cartilaginous parts of animals; they were dried, and afterwards melted into tablets. It is, however, found, that all animal ſubſtances containing jelly, are capable of being made uſe of in the manufactory of glue; and du Hamel likewiſe informs us, that hartſhorn and bones, after having been diſſolved in Papin's digeſter, afforded a glue of great ſtrength, but of a black colour.

That glue might be extracted from bones, we are informed by Papin himſelf. In the edition of his works printed in 1782, it is ſaid, that, by means of his digeſter, he had not only prepared a jelly from bones, but alſo from ivory, with which he had glued together ſome pieces of broken glaſs; and from experiments that have been ſince made upon them, it appears they contain it in a conſiderable quantity. Papin.

Spielman has added a good deal of information to that found in Papin on this ſubject. According to this chemiſt, he has extracted glue, or dry jelly, not only from the bones, but all the hard parts of animals, ſimply by ebullition; that he procured more or leſs of it from the teeth of the wild boar, thoſe of the ſea horſe, and likewiſe from the wood-louſe, and the viper. Spielman.

There are ſeveral ſorts of glue made in Europe. The Engliſh glue is eſteemed the beſt; it is of a browniſh red colour. The Flanders is looked upon as next in point of goodneſs; it is whitiſh and tranſparent, whilſt the moſt ordinary is made at Paris, and is black and opake. The reaſon of this difference, according to Lewis, ariſes from the Flemiſh and French employing bones and ſinews, which do not afford ſo ſtrong a glue as ſkins, from which the Engliſh manufacture their glue. According to this chemiſt, the method of preparation is, to ſteep and waſh the parings or cutting of the hides in water; they are then boiled with freſh water till the liquor grows thick, when it is ſtrained through baſkets, ſuffered to ſettle, and afterwards further evaporated, till, on being poured into flat moulds, it unites, on cooling, into ſolid cakes, which are cut in pieces and dried upon a kind of net. Lewis.

Grenet has been occupied for ſeveral years with the melioration of this ſubſtance; he began by reading every thing already written on the ſubject; meditated very much on the qualities of the ſubſtances employed; and ſubmitted to experiment thoſe which had not been made uſe of, Grenet.

and which appeared to him to be proper for it's preparation. Bones, however, produced it abundantly, and with great facility; he firſt deprived them of their fat, and procured the jelly by ſimple ebullition; and this, when converted into glue by drying, he found to be much ſuperior to the French kind, and nearly equal in goodneſs to thoſe of the beſt markets.

Parmentier. Parmentier, and Pelletier, who have alſo made experiments tending to the ſame end, obtained from 6lbs. of raſpings of the button makers, 1lb. of glue, ſimilar to the Engliſh ſort. From the raſpings of ivory the glue was more coloured, but equally as good. The raſpings of horn they found to afford no glue.

As jellies acquire more or leſs colour by expoſure to heat, on being brought to a proper ſtate of exſiccation, to procure glue as little coloured as poſſible, the leſs time it is expoſed to heat the better; hence, by uſing only a ſmall quantity of water to extract the jelly, a leſs evaporation is neceſſary to concentrate it, ſo as to form that ſubſtance on cooling, and conſequently a leſs expoſure to the fire; and if the jelly be afterwards cut into thin tablets or cakes, they will likewiſe be more eaſily dried. To following this plan, the Flanders glue is ſaid to owe it's whiteneſs and tranſparency; whereas by much expoſure to heat, the parts become carbonized and black.

Glues differ from each other in their conſiſtence, colour, ſavour, odour, and ſolubility; ſome of them diſſolve very readily, when agitated in cold water, others are only ſoluble in boiling water; the beſt ought to be tranſparent, of a yellow, inclining to a brown colour, without odour or ſavour; it ſhould be perfectly ſoluble in water, forming a viſcous fluid with it of an uniform conſiſtence, and which on becoming dry, preſerves equally, in every part, it's tenacity and tranſparency, and, in general, attains more ſolidity, colour, and viſcidity, according to the age and ſtrength of the animal from which it has been extracted.

Clennel. Clennel has given the moſt minute account of the making of glue, which was obtained during a viſit to a manufactory in Southwark. He informs us, it is made from the parings of hides, horns of different kinds, pelts from furriers, and the hoofs and ears of horſes, oxen, calves, ſheep, &c. quantities of which are imported in addition to the home ſupply, by many of the great manufacturers of this article. Theſe are firſt digeſted in lime-water to cleanſe them, as far as it can, from any greaſe and dirt; they are then ſteeped in clean water, ſtirring them well from time to time; they are afterwards laid in a heap, and the ſuperabundant water poured out; they are then boiled in a large braſs caldron with clean water, ſkimming off the dirt as it riſes, which is further cleanſed by putting in, after the whole is diſſolved, a little melted alum, or lime finely powdered, which, by their deterſive properties, ſtill further purge it; the ſkimming is continued for ſome time, when the maſs is ſtrained through baſkets and ſuffered to ſettle, that the remaining impurities, if any, may ſubſide; it is then poured gently into the kettle again, and further evaporated, by boiling a ſecond time, and ſkimming, until it becomes of a clear but darkiſh brown colour; when it is thought to be ſtrong enough (which is known either by the length of time a certain quantity of water and materials have boiled, or by it's appearance during ebullition), it is poured into frames and moulds about ſix feet long, one broad, and two deep, where it hardens gradually as the heat decreaſes; out of theſe troughs or receivers, it is cut when cold by a ſpade, into ſquare pieces or cakes, and each of theſe placed within a ſort of wooden box, open in three diviſions to the back; in this the glue, as yet ſoft, is taken to a table by women, where they divide it into three pieces, (when, by miſtake, they cut only two, that which is double the ſize is called a biſhop, and thrown into the kettle again) with an inſtrument, not unlike a bow, having a braſs wire for it's ſtring; with this they ſtand behind the box, and cut by it's openings from front to back; the pieces thus cut, are taken out into the open air, and dried on a kind of coarſe net work, faſtened in moveable ſheds of about four feet ſquare, which are placed in rows in the gluemaker's field, (every one of which contains four or five rows of net work); when perfectly dry and hard it is fit for ſale.

According to Clennel, that is thought the beſt glue which will ſwell conſiderably without melting, by three or four days immerſion in cold water, and recover it's former dimenſions and properties by drying. Glue that has got froſt, or that looks thick and black, may be melted over again and refined, with a ſufficient quantity added of freſh, to overcome any injury it may have ſuſtained; but it is generally put into the kettle after what is in it has been purged in the ſecond boiling. To know good from bad glue, the purchaſer ſhould hold it between his eye and the light, and if it appears of a ſtrong dark brown colour, and free from cloudy or black ſpots, the article is good.

Size.

A ſuperior and even colourleſs glue, called *ſize*, is obtained from eel-ſkins, vellum, parchment, and ſome of the white kinds of leather, &c. but this is much too expenſive for common uſe, and is only employed by thoſe artificers whoſe work requires ſo delicate a ſubſtance, and where glue would be too groſs. Such as uſe ſize are the paper-maker, the linen manufacturer, the gilder of gold, poliſher, and the painter in various colours, &c. For the ſame purpoſe the ſkins of the cat, rabbit, and hare, are employed.

Hatchett on mucilage, ſize, and glue.

Hatchett, in his experiments to inveſtigate the compoſition of membrane, obtained various quantities of gelatin, and when the ſolutions of it were gradually reduced by evaporation, he had opportunities of frequently obſerving the various degrees of viſcidity and tenacity which characterize mucilage, ſize, and glue. The difference in the viſcidity and tenacity of the varieties of theſe ſubſtances, is, according to this chemiſt, evidently an inherent quality, and not cauſed by the degree of inſpiſſation; for if this was the caſe, mucilage, ſize, and glue, when dry, he thinks, would be of equal quality, which is contrary to experience; for the varieties of glue are not of equal tenacity. Glue, made from certain parts of animals, ſuch as the ſkin, being more tenacious and of better quality than that which is made in ſome places from feet and ſinews. It differs alſo according to age; for the beſt and ſtrongeſt glue is always obtained from the more aged animals, in whom the fibre is found to be moſt coarſe and ſtrong. But a longer continued boiling appears requiſite to extract it, and the more viſcid glues are obtained with greater difficulty than thoſe of a leſs viſcid quality, which may more properly be called ſize, and this difference is to be obſerved, when muſcle is boiled with repeated and frequent changes of water. Gelatin thus obtained, whether in the ſtate of mucilage, ſize, or glue, when completely dried, is affected by water according to it's degree of viſcidity; for when cold water is poured on dry mucilage, it diſſolves it in a ſhort time; but if cold water is poured on theſe varieties of gelatin, which when diſſolved in a proper quantity of boiling water, would, by cooling, form jellies more or leſs ſtiff, it acts on them in different degrees, not ſo much by forming a complete ſolution, as by cauſing them to ſwell and become ſoft; ſo that when a cake of glue has been ſteeped three or four days in cold water, if it ſwell much without being diſſolved, and, when taken out, recovers it's original figure and hardneſs by drying, ſuch glue is conſidered to be of the beſt quality.

The animal mucilage, which Hatchett employed, was obtained from the coroll. officin. as he found it to be pure, and not partly modified into gelatin or animal jelly; or in other words, the mucilage had not acquired the degree of viſcidity requiſite to form a gelatinous ſubſtance. The expreſſion is not therefore to be underſtood as alluding to any eſſential difference in compoſition, but only to denote ſome variation in the degree of conſiſtency; for the whole may be comprehended under the term gelatin, (vide art. Gelatin) of which mucilage may be regarded as one extreme, and the ſtrongeſt and moſt viſcid glue as the other.

As the qualities of gelatin are ſo various, ſo the properties of the ſubſtances in which it is preſent as a component part, are much influenced by it; and when, for example, ſkins of different animals are compared, he always found, that the moſt flexible ſkins afforded gelatin more eaſily, and of a leſs viſcid quality, than thoſe which were leſs flexible, and of a more horny conſiſtency. The ſkin of the eel poſſeſſes great flexibility, and it affords gelatin very readily and in large proportion. The ſkin of the ſhark alſo, which is commonly uſed by cabinet makers to poliſh their work, was alſo ſoon diſſolved, and formed a jelly like the former. The thin and tender epidermis or cuticle of theſe ſkins, although not ſoluble, was reduced into ſmall particles by violent ebullition, and the ſpiculæ were alſo ſeparated. The ſkins of the hare, rabbit, calf, ox, and rhinoceros, gave the ſame reſults, but gelatin from the hide of the rhinoceros, appeared the ſtrongeſt and moſt viſcid. In every one of the experiments, the true ſkin, or cutis, was principally affected (as Chaptal and Seguin have obſerved) by long boiling, but that of the rhinoceros far exceeded the others in difficult ſolubility. The cutis of theſe ſkins, when firſt boiled, ſwelled and appeared horny; it was then gradually difſolved; but in the cutis of the rhinoceros a few filaments remained, which at length contracted and adhered to the cuticle. The cuticle of the different ſkins was ſoftened, but not diſſolved; and as the cutis ſeems to be entirely formed of gelatin, ſo the cuticle appears to contain it, although in a ſmall proportion. It is, however, neceſſary to it's flexibility, ; for when, after long boiling, the cuticle of the ſkins was dried, it became a brittle ſubſtance, which was eaſily reduced to powder.

Hair was much leſs affected than ſkin. The cartilages of the articulations are as completely ſoluble as the cutis, when long boiled with water; but this is not the caſe with the other cartilages; the other afforded little or none. It was the ſame with reſpect to quill ſhavings, and the horns of different animals, which were next ſubjected to experiment, and all afforded ſmall quantities of gelatin, and the more flexible horns the greateſt quantity, with the greateſt eaſe, and, when deprived of it, and ſuffered to dry ſpontaneouſly, in the air, they become more rigid, and were eaſily broken. The horns were thoſe of the ox, ram, goat, and chamois, which are perfectly diſtinct from the nature of ſtags or bucks horn; for this is as different from the former, in chemical compoſition as in conſtruction. Like bone, it affords much phoſphat of lime, (vide bone) and like it, a large quantity of gelatin; and it is obſerved by Hatchett, that phoſphat of lime is generally accompanied by gelatin, as in ſtags horn, bone, ivory, &c. On the contrary, when carbonat of lime is the hardening ſubſtance, as in ſhells, madrepores, and millepores, no gelatin can be diſcovered; for he has frequently digeſted the ſubſtances many days in boiling diſtilled water, after having reduced them to a coarſe powder, that they might preſent a large ſurface, but never could diſcover the ſlighteſt veſtige of gelatin. Hence the above horns are very different from the compoſition of ſtags horn, and yield gradually, and with great difficulty, only a ſmall quantity of gelatin.

Human nails and ſhavings of a hoof, long digeſted for ſeveral days, afforded like quill, only a ſlight cloud by nitro-muriat of tin. Tortoiſeſhell in ſmall thin ſlips and ſhavings were affected in a ſimilar manner.

Sponges and gorgoniæ, bladder and other membranes, afforded more or leſs gelatin.

He found the effects of the dilute nitric acid on the ſubſtances he ſubjected to experiment for the obtaining of glue, exactly kept pace with thoſe of boiling water, of which he gives an inſtance of two pieces of ſkin recently taken from the ox, one of the pieces was boiled in water till the whole of the cutis was diſſolved ; after which the cuticle remained, although very feeble in texture, while the hair did not ſeem to have ſuffered any material alteration. The other piece was ſteeped in nitric acid, diluted with about four meaſures of diſtilled water. At the end of five days the cutis was diſſolved, and the cuticle was become of a looſe and feeble texture, but the hair had not ſuffered any apparent change excpting that of being ſlightly tinged with yellow. In both caſes, therefore, the effects of boiling water, and of acid, were ſimilar ; and he found them to be more powerful on thoſe parts which were the moſt gelatinous ; and as water diſſolves mucilage more ſpeedily than ſize, and this laſt more ſpeedily than ſtrong viſcid glue, ſo are the effects of very dilute nitric acid on the ſame ſubſtances.

In reſpect to œconomical purpoſes, all animal ſubſtances whatever, (excluſive of carbonat and phoſphat of lime) may be converted into two ſubſtances of much utility, viz. glue and ſoap, with the additional advantage that thoſe parts which would be rejected in making the one, are the moſt proper to prepare the other. The offenſive ſmell of Chaptal's ſoap is conſidered as an objection, but this may be removed by expoſing the ſoap for ſome time in flat veſſels to the air; after which, it may be reduced to the proper degree of conſiſtency by a ſecond boiling.

ISINGLASS OR ICHTHYOCOLLA.

Iſinglaſs, and the method of making it.

THIS is another fine ſpecies of glue, extracted from certain fiſh, very common in the Ruſſian ſeas, and which are found on entering the large rivers. Hence the Wolga, Lyak, the Don, and Danube, afford large quantities, as well as the Caſpian ſea; they are even to be found in Siberia, known by the name of kle or kla, from being filled with the gluey matter. It is prepared in Moſcovy from the air bladders of the *ſturgeon* and the *ſterled*, which afford the moſt beautiful iſinglaſs. After theſe, a fiſh called *ſerrijouga* gives the next in quality; and laſtly, the *belouga*. There is likewiſe another part of the fiſh ſituated near the back, to which it is attached, called the *veſiga*, which makes excellent iſinglaſs, and this is ſaid to be particularly the caſe with the fiſh *accipenſer*. It is perhaps the *ſounds* of the Engliſh.

In general the fiſh of freſh water is preferred, affording an iſinglaſs which is more delicate, more flexible, and exceedingly tranſparent; and there are numbers of ſmall ones in the above rivers which excel in affording it in a ſuperior degree.

The method of making the iſinglaſs is, after the bladder has been extracted, it is waſhed with water to clean it of the blood, if any remains, but not otherwiſe. It is then cut lengthways, and the exterior membrane taken off, which is of a brown colour, whilſt the other membrane, already mentioned, is ſo fine and white as to be taken from the fiſh with difficulty. They are firſt formed into rolls of the thickneſs of the finger, placing the fine membrane in the middle, and are then ſuſpended in the air to dry gradually. Iſinglaſs is, however, converted into various ſhapes, as fancy directs. The beſt is made in the ſummer, as it is apt to have a diſagreeable odour, if formed during the winter; at the ſame time, it diminiſhes in weight, and it's gelatinous qualities are affected. In order to be good, iſinglaſs ſhould be white, ſemitranſparent, without odour, and perfectly dry. To diſſolve it, it is reduced to ſmall pieces by breaking it with a hammer, and then cut with ſciſſars. In this ſtate it may be diſſolved in water, by a gentle heat, ſtirring it at times. It diſſolves beſt, however, in ſpirit of wine, in which it particularly differs from common glue. The Ruſſians have another kind of iſinglaſs, in the making of which, heat is uſed; it comes from Gouriefgorodon, a ſmall town on the Yaix, but it is of an amber yellow colour, and is not ſold in commerce.

Beſides the above mentioned parts of fiſh from which iſinglaſs is made, a ſort for the purpoſes of clarifying different wines and other liquors, is made from a variety of other fiſh, ſuch as ſea wolves, porpoiſes, ſea cows, ſharks, cuttle fiſh, whales, and all other fiſh without ſcales. Of theſe, the head, tail, bones, or cartilages, fins, ſkin, and indeed every part of the body, except the fleſh and fat, or oil, are boiled in a large quantity of water, ſo as to prevent any acceſs of ſmoke. It muſt be well ſhimmed in proportion as impurities ariſe. When all the viſcous part is extracted, it is taken from the fire and left to repoſe, and afterward filtered through a linen cloth. The clear filtered liquor is expoſed to heat a ſecond time, until it is become ſo thick, that if a drop be placed on a plate, it fixes on cooling. It is then taken off the fire and left till it has acquired a certain conſiſtence by cooling, when it is poured on tables of ſtone or marble, or other hard bodies, from which it may be eaſily ſeparated, and at a proper time before all the heat is diſſipated, it is cut into tablets, and dried in the ſhade. This ſort of iſinglaſs, which, if properly made, is white and tranſparent, and on diſſolving affords no ſediment, is very ſerviceable in the clarifying of wine, fixing the matter in the compoſition of crayons, and for other purpoſes, ſuch as the ſtiffening of ſilk and gauzes, the joining pieces of glaſs, or porcelane; making artificial pearls, and forming Engliſh ſticking plaſter. Iſinglaſs is of all ſhades, from a perfect tranſparency to a black; but the worſt pieces are large and yellowiſh, of a diſagreeable odour, and opake. A beautiful black may be given it by carbonizing it in a ſmall degree.

It's component parts.

According to Hatchett, 500 grains of iſinglaſs, perfectly exſiccated, yielded 56 grains of coal, from which 1 grain and half of earthy reſiduum were obtained by incineration, which laſt being deducted, the proportion of coal appears to have been 54,50 grains. The 1,50 grs. were phoſphat of ſoda, mixed with a very minute *proportion of phoſphat of lime*.

Newmann's Chemiſtry—Rapport fait au Bureau de Conſult. ſur le Colle forte des os propoſé, par M. Genet, par M. Parmentier, et Pelletier. an. dech. v. 13, p. 192. —Macquer's Wœrterbuch, art. *Leim.*—Encyclop. Méth. Arts et Métiers. t. 3, p. 60.—Nicholſon's Journal, No. 8, Oct. an account of the art of making glue.

HARD PARTS.

The principal uſe of theſe parts is to defend or ſupport the animal, which, from their firm and fixed nature, they are capable of performing. They may be divided into bones, horn, ſhells, and zoophytes.

BONES.

Bones.

These are the hardeſt and moſt firm of all the parts of an animal, their texture is cloſe and compact, more or leſs brittle, very little if in any degree flexible, and not capable of being ſoftened by heat, like horn, ſo as to receive the impreſſions of different figures. When clean and in a healthy ſtate, they are white; when diſeaſed, yellowiſh, brown, or blackiſh, very porous, and often corroded.

Expoſed to a boiling heat.

Bones, when deprived of their marrow (vide *fat*) and expoſed to a boiling heat in water, afford a quantity of gelatin, and this is eaſier extracted if they be previouſly broken into ſmall pieces or raſped (vide *glue.*)

Their diſtillation.

By diſtillation in a retort, there ariſes an alkaline phlegm, a fetid empyreumatic oil, and much concrete volatile alkali; a black coal remains behind, which is very compact and very difficult to incinerate.

Calcination.

The aſhes are white, and afford to cold water a ſmall quantity of cretaceous ſoda; hot water afterward takes up a certain quantity of ſelenite; the reſidua of theſe lixivia is inſoluble in water, and is the phoſphat of lime diſcovered by Gahn of Stockholm, in 1769. Unleſs the fire be long continued and very ſtrong, the large entire bones ſtill remain black in the middle; and if calcined in a furnace, in the midſt of charcoal, they remain luminous in the dark. By a very ſtrong heat, they are ſemi-vitrified, and reduced into a very hard and white kind of porcelane.

Action of acids.

Acids when diluted make them flexible and tough like leather, by decompoſing the calcareous phoſphat they contain, by which means they are deprived of their earth. It was by means of the vitriolic acid, that Gahn, firſt mentioned, made the diſcovery, and by this he ſeparated the phoſphoric acid. Kunckel and Beccher, who procured it from teeth, knew of it's exiſtence in bones.

Vitriolic.

In 1777, phoſphorus was prepared from bones by the means of this acid, by the chemiſts of Dijon, viz. Morveau, Marets, and Durande. For this purpoſe, bones of the ox, calf, ſheep, &c. were placed in ſtrata upon charcoal, in a furnace, and calcined, by which it was found that 41lb. of dried bones afforded nearly 24lb. perfectly calcined to whiteneſs. Theſe were then pulverized in an iron mortar and ſifted; 12lb. were taken and put into a ſtone-ware pan, common concentrated vitriolic acid was poured upon them until the effervefcence ceaſed, and there was even a ſmall exceſs; the mixture was then agitated, a ſufficient quantity of water was added to favour the action of the acid, until it was become of the conſiſtence of a clear ſoup, and it was then expoſed for three hours to the heat of a ſand bath. This laſt, however, may be diſpenſed with, by letting it ſtand at reſt for ſeveral hours, until it proves thick.

Preparation of phoſphorus.

It is then diluted with a good deal of water, and filtered through cloth or paper, taking care to waſh the reſiduum with warm water until it paſſes through taſteleſs, and no longer precipitates limewater, which proves that it no longer contains diſengaged phoſphoric acid. The filtered liquor being evaporated, gradually depoſits a beautiful white ſilky ſubſtance, which is ſelenite, and muſt be ſeparated by filtration, taking care to waſh it with a ſufficient quantity of water to carry off any phoſphoric acid that may adhere to it. The filtrations are repeated until the fluid depoſits no more precipitate; it is then evaporated to the conſiſtence of honey, when it appears with a brown and greaſy aſpect. If it be gradually heated in a crucible till it ceaſes to emit a ſulphureous, and as it were an aromatic ſmell, and no longer boils, it acquires a ſemivitreous conſiſtence, is of an acid ſavour, and attracts hnmidity from the air. Expoſed to a great degree of heat, it is fuſed into a tranſparent, hard, inſipid, inſoluble matter, without any acidity. The above quantity of bones afforded about 2 lb. 9 oz. of this ſemivitreous maſs, independent of what adhered to the crucible.

This vitreous maſs well pulverized, and mixed with one third it's weight of powdered charcoal, is put into an earthen retort, to which a receiver half filled with water, and pierced with a ſmall aperture is adapted; the fire is then increaſed by degrees till the retort is heated to whiteneſs, at which time the phoſphorus paſſes over in drops. The whole operation is from five to ſeven or eight hours, according to the quantity of matter diſtilled, and the heat the furnace is capable of giving. From the above quantity, 6 oz. 7 drachms of beautiful phoſphorus were obtained. Fourcroy ſays, that from 6 lb. of bones, 20 ozs. or a little more of the vitriform reſidue is obtained, which afford about 3 oz. of phoſphorus, and a few drachms of phoſphorus half decompoſed, which is nearly the ſame as the above. It is not neceſſary for the making of phoſphorus to carry the operation further than till the matter has acquired the conſiſtence of ſirup, which may be conveniently performed in a copper veſſel, and inſtead of a receiver, the neck of the retort may be juſt plunged ſimply in water contained in an open baſin. Care muſt be taken that the neck of the retort be not plunged ſo deep as that the water may riſe into the body of the veſſel when abſorption takes place, but that the fluid in the baſin, may, by it's fall, ſuffer air to enter; in this caſe a ſmall quantity of the phoſphorus in the neck of the retort, may be burnt, but the quantity loſt is very inconſiderable.

Experiments with the vitriolic acid were likewiſe made by Nicolas, Pelletier, Bonvoiſin, &c.

Nitrous.

It has been ſeen that the oſſeous matter may be diſſolved by the vitriolic acid. Some chemiſts have likewiſe employed the nitrous to extract the phoſphoric acid. It was by this means that Scheele ſucceeded in preparing phoſphorus ſo early as the year 1771, and he has been oppoſed to Gahn, although erroneouſly, as the firſt diſcoverer. He diſſolved, by warm digeſtion, 4 lbs. of white calcined bones, coarſely pulverized, in 8 lbs. of nitrous acid, diluted with an equal quantity of water; to this he added four times the quantity more of water, which formed nitrat of lime; the ſalt remaining in ſolution, together with the diſengaged phoſphoric acid. On this mixture he poured diluted vitriolic acid, which ſeizing the lime from the nitrous acid, formed ſelenite. This ſalt being precipitated by it's inſolubility, was ſeparated by the filter after reſting 24 hours, lixiviated, and the lye filtered and added to the firſt liquor. This was then evaporated, the ſelenite which was depoſited ſeparated, and diſtilled to the conſiſtence of ſirup; then levigated with two pounds of charcoal powder, expoſed in a retort with a receiver adapted to it, half filled with water, to a ſtrong fire, increaſed until phoſphoreſcent vapours aroſe, and the phoſphorus afterward clarified.

This method, employed by Scheele, was followed by Crell and Rouelle, who only made uſe of the vitriolic acid to precipitate the calcareous earth. This is an expenſive method, but according to Morveau, has great advantages, for the nitrat of lime being more ſoluble than ſelenite, there is no reaſon to fear that the ſalt which is produced ſhould prevent the action of the menſtruum; and ſince the vitriolic acid is only to decompoſe a liquid ſalt, there is certainty of not exceeding the quantity, which is a very important circumſtance, this acid retaining ſelenite in ſolution; and all chemiſts agree, that the more ſelenite remains in the liquor, the leſs phoſphorus is obtained. According to the ſame chemiſt, it is likewiſe very proper to *try the liquor* after it has been filtered, as Rouelle adviſes, by pouring into it a few drops of vitriolic acid, and of the nitrous ſolution of the oſſeous earth, as the firſt renders it turbid if there remains any of the nitrat of lime undecompoſed, and the ſecond diſcovers an exceſs of vitriolic acid.

Muriatic. This acid was employed by Wiegleb for the ſolution of bones, looking upon it to be more advantageous for the precipitation of the ſelenite; he, however, allows that there was ſtill ſome remaining, after the firſt diſtillation of the liquor; and it may be eaſily ſuppoſed that the muriat of lime muſt be more fixed than the nitrat of lime. Having ſeparated the ſelenite as much as poſſible by the ordinary means, he added ammonia as a further precipitant, and diſtilled in a glaſs retort the precipitated liquor, which he calls ammoniacal phoſphoric ſalt; by this means he obtained in the receiver ſome cauſtic volatile alkali, a portion of ammoniacal ſalt in the neck of the retort, and at the bottom ſome phoſphoric acid, which he ſays had attacked the glaſs; he then diſſolved it in warm water, evaporated the ſolution to dryneſs, melted it afterward in a crucible, poured out the matter which reſembled a glaſs only in appearance, and which was very acid, and deliqueſced in the air; and by this proceſs he expected a very pure *phoſphoric acid*, ſuppoſing that this acid paſſes to a glacial ſtate only from the earths which remain in it.

The method followed by Wiegleb, it is evident, is incapable of increaſing the product in the making of phoſphorus; but according to the obſervation of Morveau, it may be of ſome uſe in the preparation of *phoſphat of ammonia*. To obtain which, however, in it's pure ſtate, he has himſelf propoſed the following. Calcined bones are to be diſſolved in diluted vitriolic acid, taking care to uſe leſs acid than is neceſſary to diſſolve all the oſſeous earth. It is then to be evaporated to ſeparate the ſelenite; and if the operation be well managed, not only very little of this ſalt will remain in the liquor, but not an atom of vitriolic acid. This, however, may be tried, by adding a few drops of the nitrous ſolution of bones, which will cauſe no turbidneſs, if no acid remains. Volatile alkali is then to be added, even in it's cauſtic ſtate, ſo as to ſaturate the phoſphoric acid, which will form immediately an almoſt ſolid maſs that muſt be diluted with water, in order to filter it, and the filtered liquor is a real ſolution of phoſphat of ammonia, which, by ſpontaneous evaporation, affords very beautiful cryſtals of that ſalt, and which has been ſo laborioufly ſearched for in urine. It is, however, mixed with a ſmall quantity of phoſphat of ſoda, which ſeparates by efferveſcence in the open air. The calcareous phoſphat, remaining on the filter, may be decompoſed by the vitriolic acid for the making of phoſphorus, ſo that nothing may be loſt.

Method of obtaining phoſphorus by Morveau.

The phoſphoric acid has likewiſe been obtained from other bones beſides thoſe already mentioned. Berniard obtained it from foſſile bones; likewiſe from the bones of the elephant, whale, porpoiſe, elk, ox, teeth of the ſea-cow, the human ſpecies, and grinders of the elephant. From his experiments it appears, that all theſe bones afforded the ſame ſubſtances, and contained phoſphoric acid in different proportions. The Marquis de Bouillon obtained a phoſphoric glaſs from ivory, the head of a

A variety of bones affords it.

ſturgeon, and Fontana from the bones of fiſhes. Calcined bones generally afford one third of their weight of this acid; and Nicholas obſerves, that the bones of young animals do not contain it in ſuch large quantity as thoſe of old ones; and the ſame may be ſaid reſpecting the quantity of earth to which it is united. Thus the bones of the fœtus are ſaid to contain about one third part of earth, in the adult nearly one half, whilſt in old age it compoſes the greater part. On the contrary, the younger the animal, the greater is the proportion of gelatin in the bone. According to Accum, fiſh bones contain nearly one ſixth more phoſphoric acid than the bones of quadrupeds.

Action of alkalis.

Smith's experiment on bleaching of bones by oxygenated muriatic acid.

From the experiments of the academy of Dijon, carbonated alkalis decompoſe the phoſphat of lime in bones. A ſmall quantity of alkali is alſo uſed in bleaching them; for, when boiled in a large proportion of water, the alkali forms a ſoap with the fatty matter. But the beſt method of bleaching bones is given by Mr. Smith of Briſtol. Being ſtruck with the effects of the bleaching liquor on cotton and linen, he applied it to the whitening of bones. Having in his poſſeſſion a cranium lately prepared, perfectly clean and inodorous, but ſo brown as not to be worth preſerving, he expoſed it with the vertebræ of the neck to an oxygenated muriatic atmoſphere; for which purpoſe he adapted a cork, with a ſtop-cock driven through it, to the aperture made for the candle, at the bottom of a common lamp-glaſs. For a retort he uſed a Florence flaſk, which contained one fourth of an ounce of black calx of mangancſe, mixed with half an ounce of muriatic acid, and a long bent tube of glaſs fixed into it's neck ſerved to direct the product at pleaſure.

The ſkull had been immerſed for twelve hours in a weak cauſtic ſolution of potaſh; but he has not aſcertained whether this is abſolutely neceſſary. The lamp, which contained theſe bones thus prepared, was placed in a large trough of water. The ſtop-cock at the end afforded the means of filling it with water by exhauſting the column of air above. It now remained to diſlodge the water, by placing the flame of a ſpirit lamp under the retort, and the extremity of the tube under the lamp glaſs. In a few minutes, the yellow oxygenated muriatic acid was evolved, and, as the water ſunk, thoſe bones expoſed to it's influence, aſſumed the ſame appearance. This operation was continued till the glaſs was emptied; but it was found neceſſary to continue the proceſs ſlowly, in order to recruit the air that had been abſorbed by the preparation and water, demonſtrated by the riſing of this fluid. In ſix or eight hours the glaſs was removed, and the head, which was of a bright golden colour, was expoſed to the open air and the rays of the ſun. As it dried, it became paler, and covered with ſmall ſhining cryſtals, which were waſhed off in rain water, and the bone was become ſo beautifully white as to exceed in appearance any thing he had ſeen before of the ſame kind. With old bones this proceſs did not ſucceed ſo well as with recent; but even theſe, in ſome caſes, were well bleached. The cranium being encloſed in a dark caſe, became rather diminiſhed in it's whiteneſs, from the excluſion of the light; but this gentleman informs us, it ſtill retains it's beauty ſufficiently to demonſtrate the ſuperiority of the proceſs.

Their component parts according to Prouſt.

With reſpect to the other component parts of bones, ſome ſlight mention had been made of the preſence of a little ſelenite; and, according to Prouſt, they are compoſed of mineral alkali, ſelenite, phoſphoric lime, and a peculiar ſubſtance; but the phoſphat of lime was ſuppoſed to be the principal oſſifying matter in them.

Hatchett's experiments on bones.

A more perfect and ſatisfactory analyſis has been made by Hatchett. He obſerves, that it is ſcarcely neceſſary to mention the uſual effects of acids on bones when ſteeped in them: for it is well known, that in every operation of this nature, the oſſifying ſubſtance, which is principally phoſphat of lime, is diſſolved, and a cartilage or membrane of the figure of the original bone remains. With reſpect to the menſtrua, precipitants, and mode of operation, the bones and teeth were ſubjected to the action of the acetous, or diluted nitric and muriatic acids. The diſſolved portion was examined by carbonat of ammonia, or of potaſh, which precipitated the carbonat of lime, and the phoſphat of lime was precipitated by pure or cauſtic ammonia. In experiments, where the quantity of the ſubſtance would permit, the phoſphoric acid was alſo ſeparated by nitric or ſulphuric acid. The phoſphoric acid, thus obtained, was proved, after concentration, by experiments well known to effect ſuch purpoſes. As the principal object was to diſcover the moſt prominent character, this chemiſt did not attempt, in general, to aſcertain, minutely, the proportions ſo much as the number and quality of their reſpective ingredients.

He found that the bones of fiſh, as thoſe of the ſalmon, mackerel, brill, and ſkate, afforded phoſphat of lime, and the only difference between them, and thoſe of quadrupeds, &c. was, that the firſt appeared, in general, to contain more of the cartilaginous ſubſtance, relative to the phoſphat of lime, than is commonly found in the laſt. The different bones alſo of the ſame fiſh were various in this reſpect, and the bones about the head of the ſkate only differed from cartilage, by containing a moderate proportion of phoſphat of lime.

It is at preſent believed, that phoſphat, with ſome ſulphat of lime, conſtitutes the whole of the oſſifying ſubſtance; and he thinks it probable, that the formation of bone from cartilage depends on the phoſphat of lime; but whether this be the caſe or not, it is neceſſary to mention a third ſubſtance that occurred in the courſe of his experiments.

When human bones or teeth, as well as thoſe of quadrupeds and fiſh, whether recent or calcined, were expoſed to the action of acids, an effervefcence, although at times but feeble, was produced. This circumſtance he did not at firſt particularly notice, but the following experiments excited his attention.

After the phoſphat of lime had been precipitated from the ſolutions of various teeth and bones, by pure ammonia, he obſerved, that a ſecond precipitate, much ſmaller in quantity, was obtained by the addition of carbonat of ammonia. This ſecond precipitate diſſolved in acids with much effervefcence, during which, carbonic acid was diſengaged, and ſelenite was formed by adding ſulphuric acid. Moreover, the ſolution of this precipitate contained no phoſphoric acid, nor did the liquor from which the precipitate had been ſeparated, afford any trace of it.

This precipitate was therefore carbonat of lime; but ſtill he was not certain that it exiſted as ſuch, in the teeth and bones; and as ſulphat of lime had been already proved by former chemiſts to exiſt in bones, he was deſirous of aſcertaining, whether the carbonat of lime he had obtained had been produced from the ſulphat having been decompoſed by the alkaline precipitate, or whether the greater part had not exiſted in the bones in the ſtate of carbonat.

Each of the ſolutions in nitric acid afforded a precipitate with nitrat of barytes; but the quantity of ſulphuric acid thus ſeparated appeared by far too ſmall to be capable of ſaturating the whole of the carbonat of lime obtained from an equal quantity of the ſolution. To prove, therefore, the preſence of the carbonic acid, and the conſequent formation of the carbonat of lime, portions of the various teeth and bones were immerſed in muriatic acid at ſeparate times, and the gas produced was received in lime-water, by which it was ſpeedily abſorbed, and a proportionate quantity of carbonat of lime was obtained.

Teeth. This chemiſt then examined the enamel of teeth. When a tooth, coated with enamel, is immerſed in diluted nitric or muriatic acid, a feeble effervefcence takes place, and the enamel is completely diſſolved; ſo alſo is the bony part, but the cartilage of that part is left, retaining the ſhape of the tooth: or, if a tooth, in which the enamel is intermixed with the bony ſubſtance, be plunged into the acid, the enamel and the bony part are diſſolved in the ſame manner as before, *i. e.* the enamel is completely taken up by the acid, while the tooth, like other bones, remains in a pulpy or cartilaginous ſtate, having been deprived of the oſſifying ſubſtance. Conſequently, thoſe parts, which were coated or penetrated by lines of enamel, are diminiſhed in proportion to the thickneſs of the enamel which has been thus diſſolved, but little or no diminution is obſerved in the tooth. This has been noticed by Hunter, who, ſpeaking of enamel, ſays, " when ſoaked in a gentle acid, there appears no griſly or fleſhy part with which the earthy part had been incorporated." Hatchet has alſo obſerved, that when raſpings of enamel are put into diluted nitric or muriatic acids, they are diſſolved without any apparent reſiduum; but when raſpings of tooth or bone are thus treated, portions of membrane or cartilage remain, correſponding to the ſize of the raſpings. According to Fourcroy and Vauquelin, 100 parts of enamel of teeth contain 43,3 of lime, 29,67 of phoſphoric acid, and 27.10 of gelatin and water.

Hatchet has alſo examined the foſſil bones of Gibraltar, as well as ſome gloſſopetræ, or ſhark's teeth. The latter afforded phoſphat and carbonat of lime; but the laſt was viſibly owing principally to the matter of the calcareous ſtrata, which had encloſed theſe teeth, and which had inſinuated itſelf into the cavities left by the decompoſition of the original cartilaginous ſubſtance.

Foſſil bones and ſhark's teeth.

The bones of Gibraltar rock he found alſo to conſiſt principally of phoſphat of lime, and the cavities have been partly filled by the carbonat of lime, which cements them together.

Foſſil bones reſemble bones which, by combuſtion, have been deprived of their cartilaginous part; for they retain the figure of the original bone, without being bone in reality, one of the moſt eſſential parts having been taken away. Now ſuch foſſil or burnt bones can no more be regarded as bone, than charcoal can be conſidered as the vegetable of which it retains the figure and fibrous texture.

Bones, which keep their figure after combuſtion, reſemble charcoal made from vegetables replete with fibre; and cartilaginous bones, which loſe their ſhape from the ſame cauſe, may be compared to ſucculent plants, which are reduced in bulk and ſhape in a ſimilar manner.

From theſe laſt experiments, this chemiſt doubts if bodies conſiſting of phoſphat of lime, like bones, have concurred materially to form ſtrata of lime-ſtone or chalk. As it appears improbable that phoſphat is converted into carbonat of lime after theſe bodies have become extraneous foſſils, he is of opinion that the deſtruction or decompoſition of the curtilaginous parts of teeth and bones, in a foſſil ſtate, muſt have been the work of a very long period of time, unleſs accelerated by the action of ſome mineral principle: for, on putting the os humani of a man brought from Hythe in Kent, ſaid to have been taken from a Saxon tomb, in muriatic acid, he found the remaining cartilage nearly as complete as that of a recent bone. The difficult deſtructibility of ſubſtances of nearly a ſimilar nature, appears alſo from the mining implements formed of horn, not unfrequently found in excavations of high antiquity.

Component parts of bones.

From theſe experiments it appears, that bones are not earthy matters, as they were formerly ſuppoſed, and that they are neither compoſed of calcareous earth and clay, as ſome chemiſts affirmed, nor of magneſia, as others were willing to imagine; but that they contain a certain quantity of gelatin, diſperſed in ſmall cavities, formed by the interval between the fibrous part which compoſes their texture; and, although they may appear to reſemble earthy ſubſtances, from their inſolubility and firmneſs, they are proved to be formed of two earthy neutral ſalts, a large quantity of phoſphat of lime, a ſmall proportion of ſulphat of lime, and ſome carbonat of lime.

Oſſification.

In the firſt origin of bones, the firſt part that is formed is a membrane or cartilage of the requiſite figure which, when the ſubſequent ſecretion of the oſſifying ſubſtance takes place, is penetrated by it, and more or leſs converted into the ſtate of bone, the nature of which is more or leſs influenced by the greater or leſs predominance of the membranous or cartilaginous part, than by any other cauſe; for it is by means of it that the bone acquires it's greater or leſs ſolidity; and, although the principal effects during oſſification are produced by phoſphat of lime, it appears, that the ſulphat or carbonat of that earth is neceſſary; and, according to Hatchett, it is curious to obſerve, that as the carbonat of lime exceeds in quantity the phoſphat in cruſtaceous marine animals, and in the eggſhells of birds, ſo in bones it is vice verſa; and he thinks, that when many accurate comparative analyſes of bones have been made, ſome may be found compoſed only of phoſphat of lime; and that thus, ſhells, containing only carbonat of lime, and bones containing only phoſphat, will form the two extremities of the chain. Thus the hard ſubſtances are by no means paſſive in the animal œconomy, being renewed and ſubject to diſeaſe, as well as the other parts, and they are conſidered by Fourcroy as real ſecretory organs, the office of which is to ſeparate from the blood the peculiar ſaline ſubſtances, and more particularly the phoſphat of lime, of which they are the reſervoir, or place of depoſition.

Further experiments of Hatchett.

Hatchett, in a ſecond paper read before the Royal Society, in London, has examined the ſubſtance of bones that remains after repeated boiling, or having been ſteeped in dilute acids. For when a bone or piece of ivory has, by long boiling in water, been deprived of a great part of it's gelatin, and is afterward ſteeped in a dilute acid, the oſſifying ſubſtance, as already obſerved, is diſſolved, and the cartilage remains, retaining the figure of the original bone; or if a ſimilar bone or piece of ivory which has not been boiled, is ſteeped in a dilute acid, (eſpecially nitric acid) the oſſifying ſubſtance is diſſolved; and at the ſame time, but more ſlowly, the gelatin is ſeparated, and cauſes the liquor to become yellow, when the phoſphat of lime is precipitated by ammonia. The cartilaginous ſubſtance that remains after the gelatin has been thus ſeparated, is not eaſily ſoluble in dilute acids, for (according to it's texture) many weeks and even months may elapſe before a ſmall part is taken up; but in concentrated nitric acid, or in boiling dilute acid, it is readily diſſolved. This ſubſtance, when dry, is ſemitranſparent like horn, and more or leſs brittle, and when ſubjected to experiment, afforded the following reſults.

1. When diſtilled, a ſmall portion of water, ſome carbonat of ammonia, a fetid empyreumatic oil, carbonated hydrogen gas, and pruſſic acid were obtained.

2. A ſpungy coal, of a gray metallic luſtre, remained;

this, by incineration, afforded a very ſmall reſiduum, which reſiduum (on examining the ſame ſubſtance in different bodies) was not always ſimilar in quantity, even in portions of the ſame ſubſtance; for 500 grains of tortoiſeſhell, taken from different ſamples, afforded from one fourth of a grain to three grains of reſiduum, which conſiſted of phoſphats of lime and ſoda; ſometimes alſo a little carbonat of lime was preſent, but he does not conſider theſe to be eſſential ingredients.

3. When boiled many days in diſtilled water, the ſubſtance was ſoftened, and the water became ſlightly turbid with nitro-muriat of tin; but no effect was produced by the tanning principle.

4. Muriatic and ſulphuric acids had little effect unleſs heated, and the ſame was the caſe with nitric acid, much diluted, (the nitric acid he employed was 1,38, and this was diluted with two, three, or four meaſures of diſtilled water) or in a ſtate proper to extract and ſeparate gelatin; but if the immerſion in the dilute acid was continued during ſome weeks, the acid gradually acquired a yellow tinge, and when ſaturated with ammonia became of a deeper colour, without having it's tranſparency diluted.

5. The ſubſtance which had thus been long ſteeped in the acid was much ſoftened, was become more tranſparent, and from being horny, was now more like a cartilaginous ſubſtance: when taken out of the acid, if it was immediately ſteeped in pure ammonia, it changed to a deep orange colour, inclining to blood red; it was gradually and ſilently diſſolved without any reſiduum, and a deep orange or yellowiſh brown coloured liquor was formed.

6. Or when taken out of the acid, if it was firſt well waſhed in diſtilled water and then boiled, it was alſo diſſolved, and formed a pale yellowiſh ſolution; this, by evaporation and cooling, became a jelly, which was

again ſoluble in boiling water, and was precipitated like gelatin by the tanning principle, and more ſlowly by nitro-muriat of tin.

7. If the nitric acid in which the ſubſtance was immerſed was not ſufficiently diluted, or if heat was applied, the whole was rapidly diſſolved, with a conſiderable effervеſcence and diſcharge of nitrous gas.

8. This ſolution was yellow like the former, the colour being intenſe, in proportion to the quantity diſſolved; and it was alſo changed to a deep orange or yellowiſh brown by the addition of ammonia, without depoſiting any precipitate, unleſs a large quantity had been diſſolved.

9. The nitric ſolutions of this ſubſtance, when evaporated, afforded much the ſame appearances as thoſe of gelatin, but the coal which remained was leſs ſpungy.

10. This ſubſtance was ſtrongly diſtinguiſhed from gelatin by the effects produced, when boiled with cauſtic fixed alkali, which formed with it an animal ſoap.

11. During the proceſs, a conſiderable quantity of ammonia was diſcharged, and if the alkali was in exceſs, ſome coal was depoſited.

12. When the animal ſoap was diſſolved, diluted with diſtilled water, and filtrated, if an acid (ſuch as the acetous or muriatic) was added, a copious precipitate was obtained, which was rediſſolved by an exceſs of acid.

13. This precipitate being collected upon a filter, appeared at firſt like a yellow or browniſh viſcid ſubſtance, which, when dry, was like a thick coat of varniſh, or dried white of egg, and in like manner was brittle, and broke with a gloſſy fracture.

14. It burned like quill or tortoiſeſhell, leaving a ſpongy coal, and when diſtilled afforded ſimilar products.

15. It was not readily ſoluble in dilute acids, and was acted upon by nitric acid and ammonia, like the ſub-

ſtânce from which it was obtained; the properties alſo of it's ſolutions in nitric acid and ammonia were ſimilar.

16. With cauſtic lixivium of potaſh, it readily combined, and again formed animal ſoap.

17. It was not quite ſo inſoluble in boiling water as quill or tortoiſeſhell, and the water in which it had been boiled was not only made turbid by nitro-muriat of tin, but yielded a precipitate by oak bark after the manner of gelatin.

Theſe experiments proved, that this precipitate was the ſame as the original ſubſtance from which it had been obtained, and that the only change it had ſuffered was that of being rendered rather more ſoluble in boiling water.

From theſe experiments it alſo appears, that this cartilaginous body was quite diſtinct from gelatin in chemical properties, and having compared them with ſome experiments on inſpiſſated albumen, (white of egg) he found they correſponded in great meaſure.

He found this to be the predominant and eſſential part in the tiſſue or web of membrane, cartilage, ſponge, the horny ſtems of gorgoniæ, horn, hair, feather, quill, hoof, nail, horny ſcale, cruſt and tortoiſeſhell, varying in the colour of the ſoaps it formed.

Experiments of Merat-Guillot.

According to the experiments of Merat-Guillot, on the comparative proportions of the component parts of different bones, of which he employed 100 parts, exſiccating the products as much as poſſible, it appears that

	Gelatin.	Phoſphat of lime.	Carbonat of lime.	Loſs.
Human bones taken from the church-yard gave	16	67	1.5	15.5
Common dry human bones that had not been in the earth	23	63	2	2

Bones of the ox	3	93	2	2
Calf	25	54	traces	21
Horſe	9	67.5	1.25	22.25
Teeth of the horſe	12	85.5	0.25	2.25
Elephant or ivory	24	64	0.1	11.15
Bones of the ſheep	16	70	0.5	13.5
Elk	1.5	90	1	7.5
Stags horn	27	57.5	1	14.5
Bones of the pig	17	52	1	30
Hare	9	85	1	5
Hen	6	72	1.5	20.5
Egg ſhells	3	2	72	23
Bones of the pike	12	64	1	23
Carp	6	45	0.5	48.5
Viper	21.5	60.5	0.5	17.5
Lobſter ſhell	18	14	40	28
Mother of pearl	2.5	0	66	31.5
Crabs eyes	2	12	60	26
Red coral	0.5	0	53.5	46.
Jointed coraline	7.5	0	49	43.5
Bone of the cuttle fiſh	*8	0	68	24
White coral	1.5	0	50	48.5

With reſpect to the gelatin of the cuttle fiſh bones, this chemiſt thinks the product is not entirely compoſed of it, but that there is a portion which reſembles in it's nature that which forms the *charpente* of the polypi, known under the name of the lithophytes.

Deſirous of knowing whence aroſe the loſs, he expoſed 100 parts of crabs eyes to a ſtrong heat, and they loſt 22 parts; hence he thinks this loſs may be attributed to the water in the gelatin; but the four remaining parts to a portion of gelatin found diſſolved in the liquid uſed in the analyſis, and to a ſmall quantity of ſaline ſubſtance, which he did not examine. To make this analyſis more complete, he intends to add to it that of the bones of carnivorous animals, ſkeletons of inſects, &c.

Diſeaſes of bones.

In ſome diſeaſes of the bones, particularly in rickets, it is well known that there is a want of the phoſphat of lime, on which account the bones become ſoft, and cannot ſuſtain the muſcular action; this happens more particularly in infancy, and as the ſerum of milk is found by Fourcroy and Vauquelin to contain this earthy ſalt, a too ſmall quantity of milk, or one that does not contain this ſalt in ſufficient proportion, may produce or aſſiſt in producing this diſeaſe. Experiments have, therefore, been made where this ſalt is deficient, to apply it to the bones as a medicine, by means of the digeſtive canals, which has been found to ſucceed. Bonhomme informs us, that on giving the phoſphat of lime to chickens, he found the bones acquired a greater degree of ſolidity and hardneſs, and their epiphyſes were much leſs ſenſible than in thoſe that were only fed in the uſual way; and having given it as a medicine to patients attacked by rickets, it produced the moſt beneficial effects. The doſe to an infant was half a drachm of the phoſphats of ſoda and lime mixed together, to be taken twice a day. It may be uſeful in fracture where there is difficulty in the formation of callus, in dentition, &c. This chemiſt likewiſe informs us, on the ſubject of the phoſphat of lime in milk, deſtined for nouriſhing the infant, that the nearer the milk is to the epoch of delivery, the more is the ſeroſity found charged with this ſalt; on the contrary, the farther it is diſtant from birth, the more it loſes of this ſubſtance, in proportion, whilſt the other nutritive parts of which milk is compoſed increaſe in an inverſe progreſſion. This is eaſily accounted for, if it be conſidered that at the time of delivery a ſoftening has been made in all the joints of the mother, conſequently a relaxation in the cartilages which unite them, and that

Phoſphat of lime in milk, and it's uſe in oſſification.

Colouring of bones.

the fractures of bones which occur at this time are ſlower in uniting than at other times. It is by ſuch means that the humours which contribute the moſt to the formation of the fœtus, it's increaſe, and nutrition, carry in themſelves the eſſential baſis of ſolidity, and the elements of oſſification; in ſhort, it is only when the oſſification is well pronounced, and the digeſtive organs of the child are ſufficiently ſtrong to effect this part of animalization, that this baſis diſappears in the maternal milk. On conſidering theſe facts, we ſhall be obliged to acknowledge the peculiar direction of nature, by which the phoſphat of lime, in particular, becomes the matter of a neceſſary ſecretion, contrived for the ſtrengthening of the organs, and the conſolidation of the firſt elements of the animal. It has been found, that the living bone may be coloured, by taking into the ſyſtem a colouring ſubſtance. This is verified with reſpect to madder, which colours the bones red. The oldeſt author that mentions this, according to Beckmann, is Lemnius, in a treatiſe, *de Miraculis Occultis Naturæ, in* 1564. He was a phyſician in Zealand, where madder has been cultivated from the earlieſt ages, and where he had an opportunity of remarking it. He ſays, the bones of animals become red by eating it's leaves. Mizaldus, who publiſhed a book at Paris, in 1566, has taken what he ſays of it from Lemnius.

In 1736, John Belchier, an Engliſh ſurgeon, (Phil. Trans. vol. 39, p. 287.) may be ſaid to have diſcovered that madder, on being taken into the ſyſtem along with food, colours the bones of a red colour. What led to the diſcovery, was the following. Having dined with a cotton printer, he obſerved that the bones of the pork, which were brought to the table, were red. On expreſſing his ſurpriſe at this circumſtance, his hoſt aſſured him that the redneſs was occaſioned by the ſwine feeding on the water mixed with bran, in which the cotton cloth had been boiled, and which was coloured by the madder uſed in printing it. Belchier, to whom this effect was new, convinced himſelf by experiment, that what had been told him was true; that the red colour of the bones aroſe from the madder, and he communicated his diſcovery to the Royal Society. This ſingularity was ſoon made known, and other experiments were tried. It was found, that beſides the roots of madder, thoſe of the galium, (yellow ladies bed ſtraw) and other plants, which have an affinity to madder, produce the ſame effects.

It appears, that the colouring takes place ſooneſt in young animals, and is ſtrongeſt where the bones are hardeſt and thickeſt. On the other hand, it does not reach the ſoft parts, and in general is not perceptible in the animal juices, except a little in the milk. Saffron or woad, with many other plants uſed in dying, have no effect in colouring theſe hard parts.

HORN.

Horn.

THE horny parts of animals are produced from the forehead, and the extremities; hence they compriſe not only the horns, commonly ſo called, but the hoofs, nails, talons, and claws; which laſt might, perhaps, afford the beſt generic characters of horn. Theſe are more or leſs dry and hard, in ſome degree flexible, very conſiderably ſo when heated, and ſo coheſive as not to be capable of being pulverized in a mortar; they may likewiſe be made to receive impreſſions of different figures, which properties, altogether, are ſufficient to diſtinguiſh them from bone. Some, however, approach nearer to the laſt; ſuch are the horns of the ſtag kind, and ſeem to form intermediate ſubſtances in point of hardneſs between bone and horn.

Neumann, who diſtilled a great variety of theſe ſubſtances, found they afforded more or leſs of the ſame products as other animal matters; he ſubjected to this proceſs the horns of the rhinoceros, ox, whalebone, hoof of the elk, &c. from which he obtained an urinous ſpirit, an empyreumatic oil, volatile ſalt, and the reſidue on calcination afforded a fixed ſaline matter. Neumann.

Geoffroy obtained, on boiling one pound of hartſhorn in water, four ounces, two drachms, and ſixty-three grains of dry gelatin; and on diſtilling one ounce of this, he got two drachms of volatile alkali in a cryſtallized ſtate; and three drachms, thirty grains of yellow volatile alkaline ſpirit, with a little dark-coloured empyreumatic oil; there remained two drachms and a half behind. Geoffroy.

Dehne obtained from eleven pounds of hartſhorn, three pounds of ſpirit and ſome oil, and the reſidue weighed ſix pounds; and Model and Gunther found in the volatile ſpirit an ammoniacal ſalt in cubic or rhomboidal cryſtals, the acid of which, Leonhardi ſuppoſes, was the oxalic or the benzoic. Dehne.

Macquer informs us, that horn is of the ſame nature as the gelatinous part of animals, except that it contains leſs water and a larger proportion of earth; but that, like bone, it may in Papin's digeſter be totally converted into a gelatinous maſs; that it affords by diſtillation the common products of animal ſubſtances, with a pretty large quantity of coal very difficult to incinerate; it's aſhes contain ſcarcely any fixed alkali. The animal oil, eſpecially the firſt that comes over, on being again diſtilled, is the oleum animale Dippelii. Of this the largeſt proportion is to be got from the horns of the hart and chamois. According to this chemiſt, theſe two ſpecies contain a larger proportion of the earth of bones, which diſtinguiſhes them from the horny ſubſtances, and forms a medium between them and bones. Macquer.

Scheele and Rouelle.

Scheele and Rouelle obtained the phoſphoric acid from calcined hartſhorn, and they looked upon it as containing more of this acid than even bones; and Nicholas prefers this ſubſtance to the coal, in the preparation of this acid. Although the coal of hartſhorn is difficult to incinerate, it undergoes that proceſs much eaſier than other horns, and nearly equal to bones, and when the coal is expoſed to a ſtrong continued heat, it is converted into very white aſhes, uſed in medicine by the name of *cornu cervi uſtum.*

Hatchett.

According to Hatchett, if horns are examined, he thinks very few will be found to contain phoſphat of lime in ſuch proportion as to be conſidered an eſſential ingredient. He does not mean ſtag or buck horns, for theſe have every chemical character of bone with ſome exceſs of cartilage; but he alludes to thoſe in which the ſubſtance of the horn is diſtinctly ſeparate from the bone, and which, like a ſheath, covers a bony protuberance, which iſſues from the os frontis of certain animals. Horns of this nature, ſuch as thoſe of the ox, the ram, the goat, and the chamois, afford after diſtillation and incineration, ſo very ſmall a reſiduum, of which only a ſmall part is phoſphat of lime, that he thinks this latter can ſcarcely be regarded as a neceſſary ingredient.

From ſome experiments made on 500 grains of the horn of the ox, he obtained after a long continued heat only 1,50 grains of reſiduum; and of this, leſs than half proved to be phoſphat of lime. Seventy-eight grains of the horn of the chamois afforded only 0,50 of reſiduum, of which leſs than half was phoſphat of lime; and he thinks that ſo very ſmall a quantity cannot influence the nature of the ſubſtances that afforded it. The ſame may be ſaid of cartilage, which does not contain the oſſifying ſubſtance, or phoſphat of lime, as a conſtituent principle, but it is mixed as an extraneous matter; and when abſent, both cartilage and horn are moſt perfect and complete. He thinks the frequent preſence of phoſphat of lime in cartilaginous ſubſtances is not a proof of it's being one of their conſtituent principles; but only that it has become depoſited and mixed with them, in proportion to the tendency they may have to form modifications of bone, or according to their viſcidity with ſuch membranes or cartilages, as are liable to ſuch a change.

Scales.

Hatchett has made ſome experiments upon the ſcales of different animals. Lewenhoeck had examined the *ſcales of fiſh* by means of a microſcope; and, as they appear to be formed of different membranaceous laminæ, and exhibit the colour and luſtre of mother of pearl, it might, as Hatchett obſerves, be expected, that they ſhould prove to be of a ſimilar nature with the ſubſtance of ſtratified ſhells, or, in other terms, that they ſhould conſiſt of membrane and carbonat of lime: but, when ſcales, perfectly clean, and ſeparated from the ſkin of different fiſh, ſuch as the ſalmon and carp, had been immerſed during four or five hours in diluted nitric acid, till they became tranſparent and perfectly membranaceous, the acid liquor being then ſaturated with pure ammonia, afforded a copious precipitate, which was proved to be phoſphat of lime. The *ſpiculæ* of the ſhark's ſkin were found to be of a ſimilar compoſition, from which he infers, that the ſpiculæ and ſcales of fiſh may be conſidered as true bony ſubſtances, in which the membranaceous parts are more predominant than in common bone.

He found, that phoſphat of lime was afforded by the ſubſtances only; for when the different ſkins, from which the ſcales and ſpiculæ had been taken, were ſeparately examined, no phoſphat of lime was obtained. The ſilver or pearly hue of fiſh ſcales is only aſſiſted and modified by the relative degrees of opacity, produced by the interpoſition of the phoſphat of lime, as the hue in pearl and mother-of-pearl is by carbonat of lime: for this peculiar luſtre principally reſides in the membranaceous part, and remains with it, when the acetous or muriatic acid is employed as a menſtruum, but is completely deſtroyed by the nitrous acid. The *horny ſcales* of ſerpents, lizards, and ſuch like animals, differ from the foregoing, as they conſiſt merely of the membranaceous or horny ſubſtance, in a more or leſs indurated ſtate, and appear to be devoid of phoſphat of lime, as an oſſifying matter. Horny ſcales in general, and the ſcales of the manis pentedactyla may be mentioned as an example. They afford but very ſlight traces of gelatin after being boiled in diſtilled water, and this ſmall portion of gelatin can only be diſcovered by the tanning principle and by nitro-muriat of tin, unleſs a very large quantity of the ſcales has been employed. The hornlike cruſt, which covers certain inſects and other animals, were examined with reſpect to the gelatin they contained, particularly the plates which covered the body of a large African ſcorpion, which were not apparently affected, although digeſted for a long time in boiling diſtilled water. The tanning principle produced no alteration, when added to the water; but a faint white cloud appeared, upon the addition of nitro-muriat of tin.

SHELLS.

THESE appear to be of a much leſs compact texture than the bony and horny parts, and want not only the hardneſs of one but the flexibility of the other; they are much more brittle, and are eaſily reduced to a powder. They may be divided into the ſhells of eggs and the ſhells of animals. Shells.

EGG SHELLS.

ALTHOUGH all eggs, which are produced by birds, are provided with a ſhell, it has been obſerved, that very fat hens will ſometimes lay them deprived of this hard covering; but the reaſon of this exception is unknown. The ſhell is compoſed of gelatin, phoſphat, and carbonat of lime; it has, however, been ſuppoſed, that the phoſphoric acid ariſes from the gelatinous matter, and is not united with the earth, as in bones; the truth of which future experience is to determine. Waſſerberg obſerved that, on uſing the vitriolic acid as a menſtruum, there aroſe a ſmell of ſulphur. Vide Fæces. of eggs,

SHELLS OF ANIMALS.

Theſe, like the ſhells of different eggs, are of various colours, but far exceed them in beauty as well as in utility. Till lately, however, very little was known with reſpect to their component parts. of animals.

Neumann.

According to Neumann, they yield leſs oily and ſaline matter by diſtillation than either horn or bone; he has alſo obſerved, that ſome are more eaſily converted into quicklime by fire than others, whilſt a few ſuffer no such change.

Hatchet's experiments.

For the beſt analyſis of ſhells we are indebted to Hatchett, whoſe experiments were made on thoſe of marine animals; and the menſtrua, precipitants, and mode of operation he made uſe of, were the following.

Their diviſion into two kinds.

The ſhells he examined he divides into two kinds, from the ſubſtance of which they are compoſed. The firſt have a porcellaneous aſpect, with an enamelled ſurface, and, when broken, are often in a ſlight degree of a fibrous texture. Theſe porcellaneous ſhells are the various ſpecies of voluta, cypræa, and others of a ſimilar nature. The ſecond kind have, generally, if not always, a ſtrong epidermis, under which is the ſhell, principally or entirely compoſed of the ſubſtance called *nacre*, or mother-of-pearl, ſuch as the oyſter, the river muſcle, the *haliotis iris*, and the *turbo olearius*.

Theſe were immerſed in acetous acid, or nitric acid diluted, according to circumſtances, with 4, 5, 6, or more parts of diſtilled water; and the ſolution was always made without heat.

The carbonat of lime was precipitated by carbonat of ammonia, or of potaſh; and phoſphat of lime (if preſent) was previouſly precipitated by pure or cauſtic ammonia.

If any other phoſphat, like that of ſoda, was ſuſpected, it was diſcovered by ſolution of acetite of lead.

Tortoiſe-ſhell.

500 grains of tortoiſe-ſhell yielded 80 grains of coal; from which 3 grains of earthy matter being deducted, 77 grains remain for the proportion of coal. Theſe three grains conſiſted of phoſphat of ſoda and lime, with ſome traces of iron; but Hatchett thinks it probable that the

latter was accidentally preſent. Tortoiſe-ſhell appears to be formed (as far as organic arrangement is concerned) in the way of ſtratum ſuper ſtratum, and this ſtructure is particularly to be diſcovered after long maceration in diluted nitric acid; for then this ſhell appears to be compoſed like the black poliſhed gorgonia, of membranaceous laminæ, and the varieties of horn differ only by a tendency to the fibrous organization.

PORCELLANEOUS SHELLS.

Porcellaneous ſhells.

SHELLS of this deſcription, when expoſed to a red heat in a crucible for about a quarter of an hour, crackled and loſt the colours of their enamelled ſurface; they did not emit any apparent ſmoke, nor any ſmell, like that of burned horn or cartilage. Their figure remained unchanged, excepting a few flaws, and they became of an opake white, tinged partially with pale gray, but retained part of their original gloſs.

Freſh ſhells (whether entire or in powder) diſſolved with great effervеſcence in the various acids, and the ſolution afterwards remained colourleſs and tranſparent; but the burned ſhells, on being diſſolved, depoſited a very ſmall quantity of animal coal; and thereby the preſence of ſome gluten was denoted, although the proportion was too ſmall to be diſcovered in the ſolution of the freſh unburned ſhells.

The various ſolutions were filtered and examined by pure ammonia and acetite of lead; but there was no trace of phoſphat of lime, nor of any other combination of phoſphoric acid.

The carbonat of lime was afterwards precipitated by carbonat of ammonia; and from many experiments it appeard, that porcellaneous ſhells conſiſt of carbonat of lime, cemented by a very ſmall portion of animal gluten.

Patellæ.

Previous to the experiments on the ſecond ſort of ſhells, this chemiſt examined ſome patellæ from Madeira. Expoſed to a red heat in a crucible, there was a perceptible ſmell, like that of horn, hair, or feathers. The proportion of carbonic matter, depoſited by the ſubſequent ſolution, was more conſiderable than that of the porcellaneous ſhells, and the proportion of carbonat of lime, relative to their weight, was leſs.

When the recent ſhells were immerſed in very dilute nitric acid, the epidermis was ſeparated, the whole of the carbonat of lime was diſſolved, and a gelatinous ſubſtance, nearly liquid, remained; but without retaining the figure of the ſhell, and without any fibrous appearance.

Theſe ſhells, therefore, contain a larger proportion of a more viſcid gelatinous ſubſtance than the porcellaneous, but the ſolution ſeparated from this gelatinous ſubſtance afforded nothing but carbonat of lime.

Pearly ſhells. Oyſter ſhell.

Pearly ſhells. In the examination of the ſhells compoſed of nacre or mother-of-pearl, he found that, on expoſing the ſhell of the common oyſter to a red heat, the effects were the ſame as thoſe obſerved in the patellæ, and the ſolution of the unburned ſhell was ſimilar, only the gelatinous part was rather of a greater conſiſtency.

Muſcles.

A ſpecies of river muſcle was next ſubjected to experiment. This, when burned in a crucible, emitted much ſmoke, with a ſtrong ſmell of burned cartilage or horn; the ſhell throughout became of a dark gray and exfoliated. By ſolution in the acids, a large quantity of carbonic matter was ſeparated, and much leſs carbonat of lime was obtained from a given weight of the ſhell, than from thoſe already mentioned.

On immerſing an unburned ſhell in dilute nitric acid, a rapid ſolution and effervefcence at firſt took place, but gradually became leſs; ſo that the diſengagement of the carbonic acid gas was to be perceived only at intervals. At the end of two days, nearly the whole of the carbonat of lime was diſſolved, but a ſeries of membranes retaining the figure of the ſhell remained; of which the epidermis conſtituted the firſt. In the beginning, the carbonat of lime was readily diſſolved, becauſe the acid menſtruum had an eaſy acceſs; but after this, it had more difficulty to inſinuate itſelf between the different membranes, and of courſe the ſolution of the carbonat of lime was ſlower. During the ſolution, the carbonic acid gas was entangled, and retained in many places between the membranes, ſo as to give the whole a cellular appearance.

Haliotis iris, and turbo olearius.

The haliotis iris, and the turbo olearius, reſembled this muſcle, excepting that their membranaceous parts were more compact and denſe. Theſe ſhells, when deprived of their hardening ſubſtance, or carbonat of lime, by an acid menſtruum, appear to be formed of various membranes, applied ſtratum upon ſtratum. Each membrane has a correſponding coat, or cruſt of carbonat of lime; which is ſo ſituated, that it is always between every two membranes, beginning with the epidermis, and ending with the laſt formed internal membrane.

The animals which inhabit theſe ſtratified ſhells increaſe their habitation by the addition of a ſtratum of carbonat of lime, ſecured by a new membrane; and as every additional ſtratum exceeds in extent that which was previouſly formed, the ſhell becomes ſtronger in proportion as it is enlarged; and the growth and age of the animal becomes denoted, by the number of the ſtrata which concur to form the ſhell.

Although the haliotis iris, and the turbo olearius, are compoſed of the true mother of pearl, this chemiſt was induced to repeat the foregoing experiments, on ſome detached pieces of mother of pearl, ſuch as are brought from China, and the reſults were preciſely the ſame.

Mother of pearl.

He, however, obſerves, that the membranaceous, or cartilaginous parts of theſe ſhells, as well as of the pieces of mother of pearl, retained the exact figure of the ſhell or piece, which had been immerſed in the acid menſtruum; and theſe membranaceous parts diſtinctly appeared to be compoſed of fibres, placed in a parallel direction, correſponding to the configuration of the ſhell.

Pearls.

The ſame experiments were made on pearls, which proved to be ſimilar in compoſition to the mother of pearl; and ſo far as the ſize would enable him to diſcern, they appeared to be formed by concentric coats of membrane, and carbonat of lime; by this ſtructure, they much reſemble the globular calcareous concretions, formed at Carlſbad, and other places, called piſolithes.

The wavy appearance, and irrideſcency of mother of pearl, and of pearl, are evidently the effects of their lamellated ſtructure, and ſemitranſparency, in which, in ſome degree, they are reſembled by the lamellated ſtone, called adularia.

Porcellaneous and pearly ſhells compared.

When the experiments on the porcellaneous ſhells, and on thoſe formed of mother of pearl, are compared, it appears, that the porcellaneous ſhells are compoſed of carbonat of lime, cemented by a very ſmall portion of gluten; and that mother of pearl, and pearl, do not differ from theſe, except by a ſmaller proportion of carbonat of lime; which, inſtead of being ſimply cemented by animal gluten, is intermixed with, and ſerves to harden a membranaceous or cartilaginous ſubſtance; and this ſubſtance, even when deprived of the carbonat of lime, ſtill retains the figure of the ſhell.

But between theſe extremes, there will probably be found many gradations, and theſe we have the greater reaſon to expect, from the example afforded by the patellæ.

Hatchett having ſtated the difference between porcellaneous ſhell and mother of pearl, thinks it is not poſſible to avoid the comparing of theſe to enamel and tooth.

Porcellaneous ſhell compared with enamel and tooth.

When porcellaneous ſhell, whole or in powder, is expoſed to the action of acids, it is completely diſſolved, without leaving any reſiduum; and enamel is alſo completely diſſolved in the like manner.

Porcellaneous ſhell and enamel, when burned, emit little or no ſmoke, nor ſcarcely any ſmell of burned horn or cartilage. Their figure, after expoſure to fire, is not materially changed, except by cracking in ſome parts; their external gloſs partly remains, and their colour at moſt becomes gray, very different from what happens to mother of pearl, or tooth. In their fracture, they have a fibrous texture; and in ſhort, the only eſſential difference between them appears to be, that porcellaneous ſhells conſiſt only of carbonat of lime, and enamel of phoſphat of lime, each being cemented by a ſmall portion of gluten.

Mother of pearl with bone and tooth.

In like manner, if the effects produced by fire and acid menſtrua, on ſhells compoſed of mother of pearl, and on the ſubſtance of teeth and bone, are compared, a great ſimilarity will be found; for when expoſed to a red heat,

1ſt. They ſmoke much, and emit a ſmell of burned cartilage, or horn.

2d. They become of a dark gray or black colour.

3d. The animal coal thus formed is of difficult incineration.

4th. They retain much of their original figure; but the membranaceous ſhells are ſubject to exfoliate.

5th. Theſe ſubſtances (pearl, mother of pearl, tooth, and bone) when immerſed in certain acids, part with their hardening or oſſifying ſubſtances, and then remain in the ſtate of membrane or cartilage.

6th. When previouſly burned, and afterward diſſolved in acids, a quantity of animal coal is ſeparated, according to the proportion of the gelatinous, membranaceous, or cartilaginous ſubſtance, and according to the duration of the red heat.

And laſtly, the acid ſolutions of theſe ſubſtances, by proper precipitants, afford carbonat of lime in the one caſe, and phoſphat principally in the other, in a proportion relative to the membrane or cartilage, with which, or on which, the one or the other had been mixed, or depoſited.

As porcellaneous ſhell principally differs from mother of pearl, only by a relative proportion between the carbonat of lime, and the gluten, or membrane, in like manner, the enamel appears only to be different from tooth or bone, by being deſtitute of cartilage, and by being principally formed of phoſphat of lime, cemented by gluten.

The difference in the latter caſe ſeems to explain why the bones and teeth of animals fed on madder became red; when at the ſame time, the like colour is not communicated to the enamel; for it appears probable, that the cartilages which form the original ſtructure of the teeth and bones, become the channels by which the tingeing principle is communicated and diffuſed. Theſe comparative experiments prove, that there is a great approximation in the nature of porcellaneous ſhell and the enamel of teeth, and alſo in that of mother of pearl and bone; and if a ſhell ſhould be found compoſed of mother of pearl, coated by the porcellaneous ſubſtance, it will reſemble a tooth coated by the enamel, with the difference of carbonat being ſubſtituted for the phoſphat of lime.

Snail ſhells.

Some few experiments were made on certain land ſhells; and in that of the common garden ſnail this chemiſt thought he diſcovered ſome traces of phoſphat of lime, but as he found none in the helix nemoralis, it may be doubted whether the preſence of the phoſphat of lime ſhould be conſidered as a chemical character of land ſhells.

Bone of the cuttle fiſh.

Experiments on the ſubſtance, called the bone of the cuttle fiſh, proves, that it is exactly ſimilar to ſhell in compoſition, and conſiſts of various membranes, hardened by carbonat of lime, without the ſmalleſt mixture of phoſphat; and of courſe is improperly called a bone.

CRUSTACEOUS PARTS.

Cruſtaceous parts.

Hatchett not being acquainted with any experiments, by which the chemical nature of the ſubſtance which covers the different cruſtaceous marine animals, as the echini, ſtar fiſh, crabs, lobſters, &c. had been determined, was deſirous to aſcertain in what reſpect it differed from ſhell; and he began his experiments on three ſpecies of echinus. He was the more inclined to begin with the echini, becauſe naturaliſts do not appear to be perfectly agreed, whether to call them teſtaceous or cruſtaceous animals; for Klein, who has written a book upon them, regards them as belonging to the firſt tribe; whilſt Linnæus, on the contrary, looked upon them as of the ſecond. Now, as the experiments above related had proved that the ſhells of marine animals were compoſed of carbonat of lime, without any phoſphat, this chemiſt thought it very poſſible, that the covering of the cruſtaceous animals might, in ſome reſpect, be different; and if ſo, he might be enabled, by chemical characters, to aſcertain the claſs to which the echinus was to be referred.

Echini. Of the three echini examined, one had ſmall ſpines; the ſecond had large obtuſe ſpines, and the third was of a very flat form.

Portions of theſe echini were ſeparately immerſed in acetous, muriatic, and diluted nitric acid, by each of which they were completely diſſolved, with much effervescence, depoſiting at the ſame time a thin outer ſkin or epidermis. The tranſparency of the ſolutions was alſo diſturbed by a portion of gluten, which remained ſuſpended, and communicated a browniſh colour to the liquors.

The ſolutions in acetous and diluted nitric acids were filtered; after which, from the acetous ſolution of each echinus, a precipitate of phoſphat of lead was obtained, by the addition of acetite of lead; and having thus proved the preſence of phoſphoric acid, the nitric ſolutions were ſaturated with pure ammonia, by which a quantity of phoſphat of lime was obtained, much inferior, however, in quantity to the carbonat of lime, which was afterward precipitated by carbonat of ammonia.

The compoſition of the cruſt of the echinus is therefore different from that of marine ſhells, and by the relative proportions and nature of the ingredients, it approaches moſt nearly to the ſhells of the eggs of birds; which, in like manner, conſiſt of carbonat, with a ſmall proportion of phoſphat of lime, cemented by gluten.

Aſterias. It remained now to examine the compoſition of thoſe ſubſtances, which are decidedly called cruſtaceous; but previous to this, ſome experiments were made on the aſterias, or ſtar fiſh, and that ſpecies was uſed which is commonly found on our coaſts, known by the common name of five fingers, or the aſterias rubens of Linnæus.

When the aſterias was immerſed in the acids, a conſiderable effervеſcence was produced, and a thin external ſtratum was diſſolved; after which, it remained in a perfectly coriaceous ſtate, and complete, in reſpect to the original figure. The diſſolved portion, being examined by the uſual precipitants, proved to be carbonat of lime, without any mixture of phoſphat; but in another ſpecies of the aſterias, with twelve rays, or the aſterias pappoſa of Lin. a ſmall quantity of phoſphat of lime was diſcovered. This chemiſt was therefore induced to ſuſpect, that in the different ſpecies of aſterias, nature makes an imperfect attempt to form ſhell on ſome, and a cruſtaceous coating on others; and that a ſeries of gradations is thus formed between the teſtaceous, the cruſtaceous, and the coriaceous marine animals.

Crab, lobſter, prawn, and crayfiſh.

It was now requiſite to aſcertain, whether phoſphat of lime were a component part of the ſubſtance which covers the cruſtaceous, marine, or aquatic animals; ſuch as the crab, lobſter, prawn, and crayfiſh.

Pieces of this ſubſtance, taken from various parts of thoſe animals, were at different times immerſed in acetous, and in diluted nitric acid; thoſe which had been placed in the diluted nitric acid produced a moderate effervеſcence, and in a ſhort time were found to be ſoft and elaſtic, of a yellowiſh white colour, and like a cartilage which retained the original figure. The ſame effects were produced by acetous acid, but in a leſs degree; in the latter caſe alſo, the colouring matter remained, and was ſoluble in alcohol.

All the ſolutions, both acetous and nitric, afforded carbonat and phoſphat of lime, although the former was in the largeſt proportion.

Cruſtaceous, compared with teſtaceous ſubſtances.

There is reaſon to affirm, therefore, that phoſphat of lime, mingled with the carbonat, is a chemical characteriſtic, which diſtinguiſhes the cruſtaceous from the teſtaceous ſubſtances, and that the principal difference in the qualities of each, when complete, is cauſed by the proportion of the hardening ſubſtance, relative to the gluten, by which they are cemented; or by the abundance and conſiſtency of the gelatinous, membranous, or cartilaginous ſubſtance, in and on which, the carbonat or the mixture of carbonat and phoſphat of lime, has been ſecreted and depoſited. Moreover, as the preſence of phoſphat of lime, mingled with carbonat, appears to be a chemical character of cruſtaceous marine animals; there is every reaſon to conclude, that Linnæus did right not to place the echini among the teſtaceous ones.

The preſence of phoſphat of lime, in the ſubſtance which covers the cruſtaceous marine animals, appears to denote an approximation to the nature of bone; which not only by the experiments of Gahn, but by the united teſtimony of all chemiſts, has been proved principally to conſiſt (as far as the oſſifying ſubſtance is concerned) of phoſphat of lime.

Concluſion.

By the experiments on various ſhells, cruſtaceous ſubſtances, and bones, it is therefore proved according to Hatchett,

1. That the porcellaneous ſhells reſemble the enamel of teeth in the mode of formation, but that the hardening ſubſtance is carbonat of lime.

2. That ſhells compoſed of nacre, or mother of pearl, or approaching to the nature of that ſubſtance, and alſo pearls, reſemble bone in a conſiderable degree, as they conſiſt of a gelatinous, cartilaginous, or membranaceous ſubſtance, forming a ſeries of gradations, from a tender and ſcarcely perceptible jelly, to membranes completely organized, in and upon which, carbonat of lime is

ſecreted and depoſited after the manner that phoſphat of lime is in the bones; and therefore as the porcellaneous ſhells reſemble the enamel of teeth, ſo the ſhells formed of mother of pearl, &c. in like manner, reſemble bone; the diſtinguiſhing chemical character of the ſhells being carbonat of lime, and that of enamel and bones being phoſphat of lime.

3. That the cruſt which covers certain marine animals, ſuch as crabs, lobſters, crayfiſh, and prawns, conſiſts of a ſtrong cartilage, hardened by a mixture of carbonat and phoſphat of lime; and that thus theſe cruſtaceous bodies occupy a middle place between ſhell and bone, although they incline principally to the nature of ſhell.

4. And laſtly, that a certain proportion of carbonat of lime enters the compoſition of bones in general; the proportion of it, however, being to the phoſphat of lime, *vice verſa*, to that obſerved in the cruſtaceous marine ſubſtances. Upon the view, therefore, of theſe facts, it is evident, that there is a great ſimilarity in the conſtruction of ſhell and bone, and that there is even an approximation in the nature of their compoſition, by the intermediate cruſtaceous ſubſtances.

Zoophytes.

ZOOPHYTES.

Examined by Bouvier and Durande.

THE component parts of the zoophytes were but little known before the experiments of Hatchett. Bouvier had, however, made an analyſis of the *corollina officinalis*; and Durande had ſomewhat inveſtigated *corollina ſubpinnata*. The firſt found, that 1000 grains of the *c. offic.* were compoſed of,

1.	Muriat of ſoda	10
2.	Gelatin	66
3.	Albumen	64
4.	Sulphat of lime	19
5.	Silex	7
6.	Iron	2
7.	Phoſphat of lime	3
8.	Magneſia	23
9.	Lime	420
10.	Carbonat of lime	196
11.	——————— magneſia ..	51
12.	Water	141
		1002

The latter procured, on diſtillation of the c. ſubpin., volatile alc. with phlegm, and an oil, and found the earth to be calcareous; he looks upon it as a plant impregnated with a large quantity of calcareous earth and animal matter.

Preliminary obſervations by Hatchett.

Hatchett, in his experiments upon the different genera of zoophytes, adopted a ſimilar mode to that which he employed in his experiments, before mentioned in this article. He obſerves, however, that as argill is not unfrequently lodged, as an extraneous ſubſtance in the interſtices of many of the madrepores, and ſuch like bodies; and as argill is precipitated by pure ammonia, it was neceſſary, not to rely merely on the ammonia, as a teſt of phoſphat of lime. Wherever, therefore, any precipitate was produced by ammonia, it was diſſolved again in acetous acid, and this ſolution was examined by the addition of acetite of lead.

It appears that the minutiæ of analyſis in the experiment did not form part of his plan, which was only to ſketch an outline, comprehending the moſt prominent chemical characteriſtics of certain bodies belonging to the animal kingdom, which hitherto had been but little or not at all examined; ſo that this outline, although defective, might ſerve as a chain of connection, and as a baſis, upon which a more perfect ſuperſtructure may in future be gradually raiſed; and it appeared to him, that this would be moſt ſpeedily and eaſily executed by following a ſyſtematic and comparative plan. For this reaſon a great part of his attention was directed towards aſcertaining, in theſe animal ſubſtances, the preſence and general proportions of carbonat and phoſphat of lime; theſe being the materials eſſentially employed by nature to communicate rigidity and hardneſs to certain parts of animals, ſuch as ſhell and bone; and although ſome other ſubſtances, as magneſia, ſilex, iron, and ſome alkaline and neutral ſalts, might be occaſionally preſent in ſmall proportions, (and indeed were at times detected) yet, as they appear to have but little influence on the general characters of the bodies which were examined, he did not think proper to take particular notice of them. The next object was, to examine the nature of the ſubſtance in and upon which the hardening or oſſifying principles were ſecreted and depoſited; and it appeared to him the beſt mode of performing it was to compare and examine this ſubſtance in the various ſtates in which it appeared, when deprived of the hardening or oſſifying matter.

From what Hatchett has ſaid on ſhell and bone, concerning the ſubſtance which remained after the carbonat of lime in ſhells, and after the phoſphat of lime in bones, had been diſſolved and ſeparated by weak acids, it is evident, that the ſubſtance which thus remains is as various in relative quantity, as it is in thoſe qualities which apparently are produced by the degrees of natural inſpiſſation, and by the progreſſive effect of organization. In the porcellaneous ſhells, ſuch as *cypreæ*, &c. this ſubſtance he proved to be much leſs in quantity than in thoſe which were afterwards mentioned, and although of a quality which, (like a cement or gluten) ſeemed to bind and connect the particles of carbonat of lime firmly together, ſo ſmall was the degree of natural inſpiſſation, and ſo little advanced was the degree of organization, that, when the carbonat of lime was diſſolved, even by very feeble acids, little or no veſtige of jelly, membrane, or cartilage, could be perceived; nor indeed could any be detected, but by the ſmall portion of animal coal which was formed, when theſe ſhells had been expoſed for a ſhort time to a low red heat.

But proceeding from ſhells of this deſcription to others tending to the nature of nacre or mother-of-pearl, (ſuch as ſome of the *patellæ*), a ſubſtance was left *untouched by the acids*, which had the appearance of a yellowiſh tranſparent jelly; ſo that the ſubſtance, which ſerved merely as a gluten in the porcellaneous ſhells, was not only more abundant in the *patellæ*, but, being more inſpiſſated, was become immediately viſible and palpable.

In the common oyſter, the qualities were more ſtrongly marked; and in the river muſcle, and in the ſhells compoſed of the true nacre or mother-of-pearl, this ſubſtance was found not only to conſtitute a large part of the ſhell, but even to be more denſe, ſo as no longer to appear gelatinous; and, in addition to theſe, ſtrong and viſible marks of organization were ſtamped on every part, and a perfect membranaceous part remained, compoſed of fibres arranged parallel to each other, according to the configuration of the ſhells.

From the facts proved by the examination of only a very few (comparatively ſpeaking) of the known ſhells, it appears, that the hardening principle or carbonat of lime, together with a ſubſtance varying from a very attenuated gluten to a tough jelly, and from this to a perfectly organized membrane, concur to form the matter of ſhell; and from the reſult of the experiments, and from all circumſtances, there is every reaſon to believe, that the ſubſtance with which, or upon which, the carbonat of lime is mixed or depoſited, is of a ſimilar nature, and differs only in relative quantity or denſity, ariſing from progreſſive changes (peculiar to the various ſpecies of ſhells) produced by certain degrees of natural inſpiſſation, and by an organization more or leſs perfect.

The experiments made on teeth and on the bones of various animals, elucidated and confirmed the obſervations made on the nature of ſhell; for,

1. The enamel of teeth (in relation to the other bony ſubſtances) was proved to be, as the porcellaneous ſhells are to thoſe formed of mother-of-pearl; the cementing ſubſtance of enamel being a gluten, in the ſame ſtate and apparently of a ſimilar nature with that of the porcellaneous ſhells. And,

2. In certain bones, particularly thoſe of fiſh, (ſuch as ſome of the bones of the ſkate) the ſubſtance, which remained after the ſolution of the phoſphat of lime, was of a gelatinous conſiſtency, and exhibited but very imperfect traces of organization; by the others, however, a com-

pletely formed membrane, or cartilage, was left, retaining the figure of the original bone.

When, therefore, the component parts of ſhell and bone are conſidered, it appears, that the eſſential characteriſtics are, carbonat of lime for the one, and phoſphat of lime for the other; and that their baſes conſiſt of the modifications of a glutinous, gelatinous, or membranaceous ſubſtance. The term jelly Hatchett only employs to denote the degree of conſiſtency of this ſubſtance, which, in it's nature, is very different from the varieties of animal jelly called gelatin.

Having traced the progreſſive and connected changes in the compoſition of the various ſhells and bones, Hatchett found his obſervations on thoſe bodies corroborated, and the chain of connection extended, by the developement of the facts reſulting from his experiments on zoophytes; and, having made the preliminary obſervations, it will be now proper to take a view of theſe experiments, and to examine how far they tend to prove, that the ſubſtances are all of a nature cloſely connected.

His experiments on madrepores.

The *madrepora virginia*, when immerſed in very dilute nitric acid, effervefced much, and was ſoon diſſolved. The ſolution was perfectly tranſparent and colourleſs, with but a ſmall appearance of gelatinous or membranaceous particles. Pure ammonia was then added, but produced no change, and the whole of what had been diſſolved, was afterwards completely precipitated by carbonat of ammonia, and proved to be carbonat of lime. The *muricata* and the *labyrinthica* afforded looſe portions of a tranſparent gelatinous ſubſtance. *M. ramea* and *m. faſcicularis*, when deprived of the carbonat of lime by acids, remained in the ſtate of completely organized and membranaceous bodies, which exhibited the original figure of the reſpective madrepores; and the proportion of coal, afforded by them, was more abundant than what was obtained from the firſt mentioned.

Millepores.

Millepora cerulea. This produced much effervescence in very dilute nitric acid. The blue colour diſappeared as the calcareous part was diſſolved, and was not afterwards reſtored by ammonia. It afforded looſe detached portions of a gelatinous ſubſtance.

M. alcicornis yielded the ſame, but in a more coherent ſtate; but it did not retain the figure of the millepore. *M. polymorpha* remained unchanged in ſhape, and conſiſted of a ſtrong, white, opake membrane, filled with a tranſparent jelly. Ammonia produced a very ſlight precipitate from the ſolution in nitric acid, which, being diſſolved in acetous acid, was proved to be phoſphat of lime, by ſolution of acetite of lead. Carbonat of ſoda afterward precipitated a large quantity of carbonat of lime. Laſtly, *m. celluloſa*, *m. faſcialis*, and *m. truncata* afforded membranaceous bodies in a complete ſtate of organization, and all the *madrepores* and *millepores*, when expoſed to a low red heat in a crucible, emitted ſmoke, with the ſmell of burned horn or feathers, became tinged of a pale or deep gray colour, and, when diſſolved in acids, depoſited more or leſs animal coal, in proportion to the quantity of the gelatinous or membranaceous ſubſtance detected by the above experiment.

The univerſal and only hardening principle of theſe *madrepores* and *millepores* was proved to be carbonat of lime, with the ſingle exception of *millepora polymorpha*, which alſo appears to be differently conſtructed from the other *milleporæ*; with this ſingle exception, carbonat of lime ſeems to be the only hardening ſubſtance in theſe bodies, and, when every circumſtance is conſidered, an exact ſimilarity is to be found between the ſubſtance forming the various ſhells, and that which forms the *madreporæ* and *millepora* ; and the nature of theſe bodies is ſo completely the ſame, that the changes or gradations of the one are to be found in the other. For the chemical characters which diſtinguiſh the porcellaneous ſhells are in a great meaſure approached by thoſe of *madrepora virginia*, and thoſe which are noticed in the *patellæ* correſpond preciſely with the madrepores and millepores, which afford a gelatinous ſubſtance; and, laſtly, the characters of the membranaceous part, exhibited by the ſhells formed of nacre or mother-of-pearl, are in like manner to be found among ſome of the madrepores and millepores; ſuch as *madrepora ramea*, *millepora faſcialis*, *m. truncata*; for theſe, like the *turbo clearius* and *haliotis iris*, are compoſed of a fibrous membrane, hardened by carbonat of lime.

It appears therefore, that the madrepores and millepores, like the various ſhells, are formed of a gelatinous or membranaceous ſubſtance, hardened by carbonat of lime, and the only difference is in the mode according to which the materials have been employed.

Tubiporæ. Of the tubiporæ he had only an opportunity of examining the *tubipora muſica*. Like the former ſubſtances, it was immerſed in an acid, and, on this occaſion, he employed the acetous acid. A great effervеſcence was produced, and the red colour was deſtroyed; in proportion as the calcareous part was diſſolved, ſome looſe particles of a tender membrane floated in the liquor. Pure ammonia produced a precipitate of argill, accidentally lodged in the interſtices of the tubipore. From the filtrated liquor, carbonat of potaſh precipitated a large quantity of carbonat of lime.

Fluſtra. When the *fluſtra foliacea* was immerſed in very dilute nitrous acid, an effervеſcence of ſhort duration took place, and when this had ceaſed, the *fluſtra* appeared like a finely reticulated membrane, which retained the original ſhape. Pure ammonia, added to the filtrated ſolution, produced a ſlight precipitate, which, diſſolved in acetous acid, was found by acetite of lead to be phoſphat of lime. On adding afterwards a ſolution of carbonat of ammonia, a copious precipitate of carbonat of lime was produced. When the fluſtra foliacea was expoſed to a low red heat in a crucible, it emitted a ſmell like burned horn, but retained its ſhape, by reaſon of the carbonat of lime, with which it was coated. The fluſtra, thus burned and diſſolved in dilute nitric acid, depoſited ſome animal coal; but in other reſpects, the preſent ſolution reſembled the former nitric ſolution of this ſubſtance, when in a recent ſtate. When the fluſtra foliacea was long digeſted with boiling diſtilled water, it communicated to it a pale browniſh tinge. Infuſion of oak bark, being poured into the liquor, did not produce any viſible effect, even after 24 hours had elapſed; but nitro-muriat of tin formed a white cloud in a few minutes.

Coralline, like the fluſtra foliacea, produced in very dilute nitric acid an efferveſcence of ſhort duration. The coralline then remained in a membranaceous ſtate, and retained the original figure. Pure ammonia produced ſcarcely any effect. Carbonat of ammonia precipitated a large quantity of carbonat of lime. Some of the coralline was then expoſed in a crucible to a low red heat, when it emitted a ſmell of burned horn, and retained in great meaſure it's ſhape, evidently from the calcareous coating. The burned coralline, diſſolved in dilute nitric acid, depoſited ſome animal coal. The clear ſolution afforded by pure ammonia a very ſlight precipitate of phoſphat of lime, after which the carbonat of lime was precipitated as before. Corallina.

The experiments, therefore, on the *tubipora muſica* prove it's reſemblance, in compoſition, to the ſubſtances before it; but a ſlight difference was obſerved in the hardening ubſtance of the *fluſtra foliacea* and *corallina opuntia*; for a ſmall portion of phoſphat was found mixed with the carbonat of lime, as firſt obſerved; but the membranaceous part of theſe bodies reſembles that of certain madrepores and millepores, particularly *millepora faſcialis*.

Iris. When the *iris ochracea* was immerſed in dilute nitric acid, a conſiderable effervеſcence was produced, and, in proportion as the calcareous ſubſtance was diſſolved, the red colouring matter was depoſited in the ſtate of a fine red powder. This colouring ſubſtance was neither diſſolved nor changed, when nitric or muriatic acid was poured upon it. It appears therefore to be very different from the tingeing matter of the *tubipora muſica*, or that of the *gorgonia nobilis*. When the effervеſcence had ceaſed, (in about three hours) a yellowiſh membrane remained, which completely retained the original figure of the iris. A ſlight precipitate of phoſphat of lime was ſeparated from the filtrated ſolution, when ſaturated with pure ammonia. A large quantity of carbonat of lime was afterward precipitated by carbonat of potaſh.

Part of a branch of this iris was expoſed to a low red heat; it ſmoked and ſmelled like burned horn, and, in a few minutes, the branch ſeparated at the knotty joints into as many pieces as there were joints in the branch. Theſe joints had all the character of coal; but the whole of the membrane, which had inveſted them, as well as the knotted protuberance, by which they had been connected, were deſtroyed, by being converted into coal. From this Hatchett was deſirous to examine the internal ſtructure of the membranaceous part, out of which theſe joints of coral had been diſſolved by acids. He therefore took the membranaceous ſubſtance, which retained the complete figure of the iris; and this, being opened longitudinally, exhibited a ſeries of cavities, correſponding in form with the coralline joints, and ſo ſituated, that each of theſe cavities extended from one bulb, or knot, nearly to the next, throughout the whole of the branch. The coralline joints, when viewed ſeparately, appeared ſmaller in the middle than at the ends, which were terminated by obtuſe cones. In the branch theſe joints were ſo placed, that the extremities or cones were oppoſed point to point, but were prevented from immediate contact by a griſtly ſubſtance, which filled, and, indeed, principally formed in the branch the knot or knob of each joint, and was interpoſed between the cones of the coralline ſubſtance, like the common cartilage of the articulations. From this conſtruction it appears, that this iris is capable of great flexibility when in a recent ſtate; for the griſtly part of the bulbs is then, moſt probably, much ſofter and more elaſtic than the dried ſpecimens. The griſtly ſubſtances, which form the bulbs and the coralline joints, are kept together and covered by a thin membrane or ſkin, continued over the whole like a tube. The joints are not therefore devoid of coating, as ſeems implied by the definition of Linnæus. *Iris hippuris* was ſimilar to the above, except poſſeſſing carbonat of lime. A tube of membrane, however, inveſts the curious ſtructure of the before mentioned iris, whilſt in this no ſuch tube or outer coat exiſts; for the coralline joints (like ſome of the madrepores, millepores, &c.) conſiſt of a membranaceous ſubſtance, hardened by carbonat of lime; and the only difference appears to be, that in the madrepores and millepores the membranaceous part is leſs compact and abundant; but even the ſtriæ of the coralline joints remain viſible and unchanged in the membrane of this iris.

The horny part forms alſo a marked characteriſtic in this iris, and ſeems to approach it to certain of the gorgoniæ. This horny part does not, however, pervade the whole of the branch; for where the coralline joints commence, this horny ſubſtance immediately terminates, internally as well externally, and is not to be diſcovered but between, or in the ſeparation of, theſe joints.

Hence both of theſe iriſes are formed of regularly organized, membranaceous, cartilaginous, and horny ſubſtances, hardened in the laſt mentioned ſpecies merely by carbonat of lime, but in the iris *ochracea* with the addition of a very ſmall portion of phoſphat of lime.

Gorgoniæ. He made experiments on different pieces of the *gorgonia nobilis,* or red coral, ſome of which were poliſhed and deprived of their external pale red mealy coat, whilſt others were in their original ſtate. They both afforded carbonat of lime, and the unpoliſhed red coral, whether in diluted nitric acid, or in acetous acid, had it's calcareous part completely diſſolved, and there remained an external tubulated membrane of a pale yellow colour, retaining the original figure, and filled with a tranſparent gelatinous ſubſtance. The poliſhed or uncoated red coral, treated in the ſame manner, left a tranſparent gelatinous ſubſtance like the other, except that it was not in detached portions. This ſolution, like the former, only yielded carbonat of lime. In each of theſe experiments the red colour of the coral was gradually deſtroyed, as the ſolution of the calcareous ſubſtance advanced, and could not afterwards be reſtored, nor could any colouring principle whatever be detected by the reagents uſually employed. When the coated or uncoated coral was expoſed to a ſlow red heat, which produced a ſmell of burned horn, it had loſt it's red colour, and became gray, and being afterwards diſſolved in dilute nitric acid, and the precipitate by ammonia again diſſolved in acetous acid, phoſphat of lead was obtained on the addition of acetite of lead. The carbonat of lime was afterwards precipitated in the uſual manner. Hence this gorgonia conſiſts of two parts, one of which is the ſtem formed of a gelatinous ſubſtance, hardened by carbonat of lime, and coloured by ſome unknown modification of animal matter; the other is a membranaceous tube, which, like a cuticle or context, coats the ſtem, and when deprived of it's hardening ſubſtance, poſſeſſes all the characters of membrane. But although carbonat of lime could only be diſcovered when this *gorgonia* was ſimply immerſed in acids, yet it appears a ſmall portion of phoſphat of lime is alſo preſent, but ſo enveloped by the membranaceous and gelatinous parts, as not to be diſſolved by the acid menſtrua, till theſe ſubſtances have been decompoſed by fire. This is not an unuſual circumſtance, when a very ſmall portion of a ſubſtance is enveloped by large quantities of other matter; for Bergman obſerves it, with reſpect to the *calculus veſicæ*, in his ſupplement to Scheele's eſſay. Hatchett does not, however, pretend to determine, whether the very ſmall portion of phoſphat of lime in this gorgonia be an eſſential ingredient or not, but the mode of conſtruction evidently proves how much this gorgonia differs from the madrepores and millepores, as well as from the following gorgonia, *G. ceratophyta.* It effervefced in dilute nitric acid, after which ſolution the cortical part appeared like a thin yellowiſh membrane, inveſting the ſtem, which was become tranſparent and ſimilar to cartilage. The ſolution afforded a large quantity of phoſphat of lime by ammonia, and lixivium of potaſh ſeparated ſome carbonat of lime. The cortex ſcarcely afforded a veſtige of phoſphat of lime, but a conſiderable quantity of carbonat. On the contrary, the ſtem afforded the phoſphat in large quantity and very little of the laſt. When burned in a crucible, it ſmelled like burned horn, but the figure was not deſtroyed; and when afterwards diſſolved in the acid, it yielded the ſame product as before. *G. flabellum.* In dilute nitric acid it's effervefcence was ſhort, and the cortical part appeared like a thin yellowiſh membrane, which covered the ſtem. The latter was tranſparent, and reſembled ſoftened horn of a reddiſh brown colour. The ſolution afforded a large quantity of phoſphat of lime, and a leſs copious precipitate of carbonat. The ſolution of the cortex was ſcarcely rendered turbid by ammonia; but afforded a conſiderable portion of carbonat of lime by potaſh. The ſtem, from which the cortical part was taken, being ſteeped three days in diluted nitric acid, became ſoft, elaſtic, and, in ſome meaſure, cartilaginous: it contained a deal of phoſphat, but very little carbonat of lime. The recent ſtem, in great meaſure, retained it's ſhape when put into a red hot crucible; but that which had been ſteeped in the acid curled up, and ſoon became a ſhapeleſs maſs of coal, which by a longer heat was completely diſſipated. This difference appears to have been cauſed by the phoſphat of lime, preſent in the recent ſtem, but diſſolved and ſeparated in the latter caſe by the acid. Hatchett obſerves likewiſe, that the different effects are to be obſerved, when bone and when the cartilage or membrane, which remains after bone has been long ſteeped in acids, are expoſed to a red heat.

Theſe experiments prove, that the *G. flabellum,* like the *G. ceratophyta,* conſiſts of a horny ſtem, containing a certain proportion of phoſphat of lime, and that this ſtem is inveſted with a membrane, hardened principally by carbonat of lime, which ſeems to cover and defend it in the manner of a ſhell. *G. ſuberoſa.* The cortical part being ſeparated from the ſtem was firſt ſubjected to experiment. In dilute nitric acid, after an effervеſcence of ſeveral hours, a ſoft yellowiſh membranaceous ſubſtance remained, retaining the original figure. The ſolution contained a little phoſphat of lime, and a large portion of the carbonat. Some of the pieces of the cortex, boiled in diſtilled water ſix hours, afforded a great deal of gelatin by means of infuſion of oak bark. The ſame pieces afterward boiled with lixivium of cauſtic potaſh were diſſolved, and formed the animal ſoap of Chaptal; the calcareous part ſubſided to the bottom. The cortical part expoſed in a red hot crucible, ſmelled like burned horn, and fell to pieces, which, being diſſolved in nitric acid, gave a little phoſphat and a great deal of the carbonat of lime. The ſtem, on being ſteeped fourteen or fifteen days in the dilute acid, tinged it of a pale yellow. After this, the ſtem was more tranſparent and flexible, approaching to cartilage; ammonia changed the yellow liquor to a deep yellow or orange colour; but there was no precipitate, even when carbonat of potaſh was added. Part of a ſtem, cut in ſmall pieces and boiled in water, afforded gelatin in ſmall quantity, and cauſtic potaſh formed with it Chaptal's animal ſoap. The ſtem, in a red heat, curled up and ſmelled like horn, and by a long continuation of the heat, the ſcarcely to be collected reſiduum diſſolved in dilute acid, gave by ammonia a ſlight portion of phoſphat of lime. Another ſpecies, which moſt reſembled the *ſuberoſa*, except that the cortical part was much longer in proportion to the ſtem, proved to be of a ſimilar compoſition with the above. *G. pectinata.* The cortical part gave a little phoſphat of lime and a large portion of carbonat. The ſtem reſembled thoſe deſcribed. *G. ſetoſa* effervеſced in dilute nitric acid, and after ſome hours, the cortical part appeared a thin yellowiſh membrane, which coated the horny ſtem. The ſolution contained a ſlight portion of phoſphat and a large one of carbonat of lime. When the cortex was ſeparately ſteeped in the acid, and the ſolution examined as before mentioned, only carbonat was obtained. On the contrary, the ſtem, whether recent or burned, gave a little phoſphat, but ſcarcely any trace of carbonat. The ſtem became in the acid ſoft and tranſparent, like cartilage. Thus the gorgoniæ already enumerated reſemble each other much in the compoſition of their cortices, as well as in the nature of their ſtems. In the cortex the predominant hardening ſubſtance is carbonat of lime; but, in the ſtem, phoſphat of lime is the chief, and almoſt the only earthy ſubſtance that is preſent.

The following *gorgoniæ*, although inveſted alſo with a cortex, are different, as they do not afford any phoſphat of lime. The *g. umbraculum*, *verrucoſa*, and three other ſpecies not deſcribed, nearly reſemble each other. Their cortical parts in dilute acid effervefced, and became ſoft, pulpy, yellowiſh white membranaceous bodies, with nearly their original form and ſize. The acid ſolutions gave no phoſphat, but a large proportion of carbonat of lime. The ſtems, left fourteen days in the acid, were very little affected, except becoming ſoft and tranſparent, reſembling cartilage or ſoftened horn; and they became of a deep reddiſh orange colour, inclining to brown, in pure ammonia, and in a few hours were completely diſſolved. The acid, in which they were ſteeped, afforded no precipitate.

The remaining *gorgoniæ* differ from the former, as they are not coated with a fleſhy or pulpy cortical ſubſtance. They are here placed immediately before the *antipathes*, on account of their great ſimilarity in chemical properties as well as in external appearance. *G. antipathes.* Some pieces of this gorgonia were immerſed in dilute nitric acid during three weeks, in which they became ſoft, and appeared to be compoſed of a pale brown, opake, membranaceous ſubſtance, which formed concentrical coats of a ligneous aſpect. The acid was become pale yellow, and ammonia changed it to orange colour; but neither it nor potaſh produced any precipitate. The gorgonia boiled ſix hours in diluted water tinged it yellow, and, on adding infuſion of oak bark, a ſmall portion of gelatin was precipitated. The pieces thus treated formed a dark coloured animal ſoap with cauſtic potaſh. The gorgonia expoſed to a red heat, ſwelled like burned horn, ſoon loſt it's ſhape, puffed up, and formed a ſpongy coal, which by a long continued heat left a few particles of a white ſubſtance, chiefly muriat of ſoda. *Another ſpecies* of gorgonia was then examined, the ſtem of which is from a quarter to nearly half an inch in diameter in the thickeſt part, of a black colour, high poliſh, like black ſealing-wax, and has probably been conſidered a variety of the *G.* antipathes. On immerſion 28 days in dilute acid, it gradually became tranſparent, of a bright browniſh yellow. In this ſoft ſtate it was ſteeped two days in water, and then opened longitudinally. By this the whole ſtructure became apparent, and conſiſted of thin coats or tubes of a beautiful tranſparent membrane, which progreſſively became larger, according to the order in which they receded from the centre. Theſe membranes were ſo delicate, that the fibrous texture could ſcarcely be diſcerned. The acid was tinged a very pale yellow, and ammonia changed it to a deep yellow or orange, but produced no change of tranſparency, or any precipitate. Expoſed to a red heat, this gorgonia crackled, emitted a ſtrong ſmoke, and ſmelled like burned horn. The ſhape was ſoon deſtroyed, and a compact coal remained. On incineration, a little white matter was obtained, and proved to be muriat and a little carbonat of ſoda. The *laſt ſpecies* of gorgonia which Hatchett inveſtigated is not eaſily to be diſtinguiſhed from the g. antipathes; but, upon a cloſe compariſon, this now treated of is more flat in the ſtem, on the thin ſides or edges of which a number of ſhort ſpines or protuberances are placed very near each other. That it is very different from the g. antipathes the following will prove. On expoſure to dilute acid for nearly four weeks, the ſtructure became apparent, and conſiſted of ſtrong fibres, nearly in a parallel direction from one extremity of the branch to the other, and being cloſely arranged ſide by ſide, formed concentric coats of a pale brown opake ſubſtance; but theſe coats were by no means ſo diſtinct as thoſe obſerved in the former gorgoniæ, although, like them, the fibrous ſubſtance poſſeſſed the character of membrane. The dilute acid was pale yellow, changed by ammonia to orange; and ſo large a quantity of phoſphat of lime was precipitated, as to make the liquor thick and viſcid. The phoſphat being ſeparated by a filter, the lixivium of potaſh had no effect on the clear liquor. The gorgonia, digeſted in boiling diſtilled water eighteen hours, tinged it pale yellow, and oak bark precipitated a little gelatin from it. The pieces employed, boiled with lixivium of cauſtic potaſh, formed a dark coloured animal ſoap; phoſphat of lime was ſeparated, and gradually fell to the bottom of the matraſs. Part of a large branch expoſed to a low red heat, ſmelled like burned horn, and being long continued, the phoſphat of lime was left, ſo as to retain the original figure, like bone which has been burned, but the particles of the maſs cohered but feebly. The reſiduum being diſſolved, and the phoſphat ſeparated, a ſlight cloud of carbonat of lime was produced by potaſh.

It therefore appears on recapitulation, from the above experiments on the various ſpecies of gorgonia, that the hardening ſubſtance of the *g. nobilis* (which was formerly looked upon as an iris) was found to be carbonat of lime, with a ſmall portion of phoſphat; but the matter forming the membranaceous part was (like that of millepora polymorpha) in two ſtates; that of the interior being gelatinous, and that of the external part being a membrane completely formed, ſo as to cover the ſame, as a tube. The reſults of the experiments on the *g. ceratophyta, flabellum, ſuberoſa, pectinata*, and *ſetoſa*, were remarkable; for, when the two parts which compoſe theſe *gorgoniæ*, viz. the horny ſtem and the cortical ſubſtance, were ſeparately examined, it was proved,

1. That the ſtems of theſe gorgoniæ conſiſt of a ſubſtance analogous to horn, and that by long maceration in diluted nitric acid, this horny ſubſtance becomes ſoft and tranſparent, ſo as to reſemble a cartilaginous or tendinous body; likewiſe the ſtems afford a quantity of phoſphat of lime, but ſcarcely any trace of carbonat.

2. That the cortical part, on the contrary, conſiſts principally of carbonat of lime, with very little or none of the phoſphat; and the carbonat of lime is depoſited in and upon a ſoft, flexible, membranaceous ſubſtance, which ſeems much to approach the nature of cuticle.

Some of the gorgoniæ ſubſequently examined, reſembling the former in conſtruction, did not yield any phoſphat of lime, but in every other reſpect were ſimilar. The G. *antipathes* was found to be entirely formed of a fibrous membrane; and the *black ſhining poliſhed gorgoniæ* afforded by maceration a moſt beautiful ſpecimen of membranes, concentrically arranged. Laſtly, the *gorgonia* Hatchett deſcribed as very much like the G. antipathes proved to be ſimilar to that ſpecies, as to the membranaceous part; but ſo large a portion of phoſphat of lime was mixed with it as almoſt to approach it to the nature of ſtag's or buck's horn; there is, therefore, great reaſon to conſider it as a different ſpecies.

Antipathes. When the *antipathes ulex* had been immerſed fourteen days in dilute nitric acid, it became tranſparent, and ſo much ſoftened, that from a horny ſubſtance it now nearly reſembled cartilage. Ammonia changed the acid to an orange colour, but produced no precipitate, neither did potaſh. A portion of the antipathes, digeſted in diſtilled water, afforded gelatin. Boiled with cauſtic potaſh, it formed the animal ſoap. *A myriophylla* afforded the ſame reſults. The ſpecimens were ſmall, which prevented him from making additional experiments; but thoſe already cited, ſufficiently prove, how much the antipathes reſemble the horny ſtems of the gorgoniæ.

Sponges.

Many ſpecies of *ſponges* were examined, but as little or no eſſential difference was found in the reſults, they may be all included in the following account. The following ſpecies, with many others not deſcribed, were inveſtigated. *Spongiæ cancellata*, *oculata*, *infundibuliformis*, *palmata*, *officinalis*. When they had been immerſed in nitric acid, diluted with three meaſures of diſtilled water, for fourteen or ſixteen days, the acid became pale yellow, and pure ammonia changed it to an orange colour. The ſponges thus ſteeped became more or leſs tranſparent, (like the gorgoniæ) and were conſiderably ſoftened. In this ſtate, the part touched with ammonia became of a deep orange colour inclining to a browniſh red, and when much ſoftened by the acid, (if afterward immerſed in ammonia) they formed a complete deep orange-coloured ſolution, and the ſame were obſerved of the horny ſtems of the gorgoniæ, antipathes, &c. When digeſted with boiling diſtilled water, the ſponges afforded a portion of gelatin, which was precipitated by infuſion of oak bark. The fine and more flexible ſponges gave it in greater abundance, and more eaſily than the coarſe or rigid ones. The gelatin was gradually and progreſſively imparted to the water, and in proportion as they were deprived of it, they became leſs flexible and more rigid, ſo that the remaining part, when dry, crumbled between the fingers, or when moiſt, was torn eaſily like wetted paper.

As theſe properties prove, that ſponges only differ from the horny ſtems of the gorgoniæ, and from the antipathes, by being of a finer and more cloſely-woven texture; (this is particularly obſervable on comparing the coarſe ſponges, as S. cancellata, with the finely reticulated parts of certain gorgoniæ, eſpecially thoſe of G. Flabellum, when diveſted of the external membrane) ſo this ſimilarity will be corroborated by the following remarks. When expoſed to heat, they afforded the ſame products, the ſame ſmell, and a ſimilar coal, which, by incineration, left a very ſmall reſiduum, chiefly of muriat of ſoda, occaſionally mixed with ſome carbonat of lime, which was alſo often diſcovered when the recent ſponges were immerſed in acids; but this, as well as muriat of ſoda, is, according to Hatchett, merely extraneous, and ariſes from ſmall ſhells, parts of madrepores and ſuch like bodies, which are often viſibly lodged in the interſtices of the ſponges. Laſtly, the ſponges, when boiled with lixivium of cauſtic potaſh, were completely diſſolved, and, like the horny ſtems of the gorgoniæ, formed animal ſoap, more eſpecially when the part which is apparently inſoluble in water, and which remains after the gelatin has been ſeparated, was thus treated.

Alcyonium.

This ſeries of experiments, made by Hatchett, terminated with an examination of a few ſpecies of *alcyonium*, viz. *aſbeſtinum*, *ficus*, and *arboreum*, all of which were found to be compoſed of a ſoft, flexible, membranaceous ſubſtance, very ſimilar to the cortical part of ſome of the *gorgoniæ* (or g. ſuberoſa), and in like manner ſlightly hardened by carbonat, mixed with a ſmall portion of lime, as the following facts will prove.

Alcyonium aſbeſtinum was unchanged in figure, after remaining ſeveral hours in dilute nitric acid; there was a feeble effervefcence, and the reddiſh purple was deſtroyed. The external part became pale yellow, and was a ſoft, opake, pulpy ſubſtance, within which was a ſtem, ſimilar in texture, but leſs ſoft, and which ſtill appeared of a pale red colour. Ammonia produced no effect on the filtered ſolution; carbonat of potaſh precipitated a large quantity of carbonat of lime. A piece in a low red heat ſoon took fire, and melted like burned horn; after which, it retained it's figure, and became white. Diſſolved in dilute acid, ſome animal coal was depoſited, and ammonia precipitated a little phoſphat of lime; after which, the carbonat was procured. A quantity of gelatin was alſo precipitated in the uſual way. On the pieces of alcyonium, from which the water had been decanted, ſome lixivium of potaſh in it's cauſtic ſtate was poured, and being boiled, the whole of the membranaceous or pulpy part was diſſolved, and a ſubſtance exactly ſimilar to Chaptal's animal ſoap was formed; while the calcareous part ſubſided to the bottom of the veſſel. *A. ficus.* This was unchanged in ſhape in the acid, and like a ſtrong, thick membranaceous ſubſtance of a fibrous texture. A little phoſphat of lime was precipitated by pure ammonia, from the acid liquor; after which, a copious precipitate of carbonat of lime was got by potaſh. *A. arboreum.* The calcareous part was ſoon diſſolved in nitric acid, but the form remained, and ſtill appeared like a pale yellow porous ſubſtance, enveloped by a ſkin or epidermis. Ammonia had no effect, but carbonat of lime was obtained by potaſh. Incinerated and diſſolved phoſphat of lime was obtained, with a large proportion of carbonat. As this phoſphat, therefore, appeared to have been defended by the membranaceous part from the acid, a complete ſolution of the alcyonium was made, and then, like that of the burned, it yielded phoſphat of lime, and the liquor became orange coloured as ſoon as the ammonia was added. A large portion of gelatin was procured, and animal ſoap formed; whilſt the calcareous part was ſeparated during the boiling, and fell down in the form of a fine powder. From this examination of the alcyonium, it appears, that as the ſponges reſemble the horny ſtems of gorgoniæ, ſo theſe ſpecies of alcyonium reſemble in external, and chemical characters, the fleſhy or cortical ſubſtance, which inveſts ſome of thoſe bodies; and that they chiefly differ from the *gorgoniæ*, by being deſtitute of the horny ſtem, which, in the latter, ſeems to ſupply the place of bone.

Concluding remarks.

From the above experiments and obſervations, Hatchett thinks there is reaſon to conclude, that the varieties of bone, ſhell, coral, and the numerous tribe of zoophytes with which the laſt are connected, only differ in compoſition by the nature and quantity of the hardening or oſſifying principle, and by the ſtate of the ſubſtance with which it is mixed or connected. For the gluten or jelly which cements the particles of carbonat, or phoſphat of lime; and the membrane, cartilage, or horny ſubſtance, which ſerves as a baſis, in and upon which the oſſifying matter is ſecreted and depoſited, ſeem to be only modifications of the ſame ſubſtance, which progreſſively graduates from a viſcid liquor or gluten, into that gelatinous ſubſtance ſo often noticed, and which again, by increaſed inſpiſſation, and by the various, or more or leſs perfect degrees of organic arrangement, forms the varieties of membrane, cartilage, and horn. The reaſons which induce Hatchett to adopt this opinion originate from a ſeries of experiments, made with a view to inveſtigate the nature and compoſition of membrane, for which, ſee *membrane*, *gelatin*, &c.

Fourcroy's Elements. vol. 4, p. 400. 1788.—Encyclop. Méthod. Chimie. tom. 1, part 1, p. 210.—Neumann's Chemiſtry, vol. 2. articles Bones, Horns, &c.—Richtens Meiung von einer beſondere Erde in den Knochen, in the Bemerk. ueber die neuer. Gegenſtande der Chemie. p. 80. Gottling's Almanack for 1793.—Weſtrumb in Crell's Chem. An. ſ. 164. 1793. —Macquer's Wœrterbuch by Leonhardi, v. 3, p. 32.

—Scheele, in Crell's Chem. Journ. th. 2, ſ. 197.—Rouelle, Journal de Méd. Oct. 1777.—Crell, in his Chem. Journ. tom. 1 & 2, p. 26, & 139.—Wiegleb, in Crell's Neueſte Entdec. t. 2, p. 6.—Analyſe de la Coralline par Bouvier, Annal. de Ch. t. 8, p. 308, & Mém. ſur la Coralline par Durande, Acad. de Dijon. ſ. 2, p. 173. An. 1783.—Experiments and Obſervations on Shells and Bone, by Charles Hatchett, F. R. S. Philoſoph. Trans. J. 1799.—On the Whitening of Bones by Mr. Richard Smith, in Beddoes Weſtern Contributions.—Cit. Bonhomme, on the Rickets. An. de Ch. tom. 18.—Analyſe comparée des Os de l'Homme avec ceux de différens Animaux par Merat-Guillot. An. de Ch. p. 68. tom. 34.—Beckmann's Hiſtory of Inventions, &c. vol. 3, p. 276. 1797.—Chemical Experiments on Zoophytes, &c. by C. Hatchett, Eſq. F. R. S. from the Philoſ. Trans. 1800.—Experiments on the two States of Phoſphat of Lime, on the Analyſis of Bone, &c. by M. Fourcroy and Vauquelin. Mém. de L'Inſtit. Nat. &c. vol, 2.

EXTERNAL PARTS.

The exterior coverings of animals, which appear to be produced for the purpoſe of retaining their heat, and as a defence againſt the inclemency of the weather, are *hair*, *wool*, *feathers*, and *ſilk*, which laſt ſubſtance ſerves to envelop the ſilk worm in it's cryſtalline ſtate.

Hair and wool.

The *hair* of different animals has been imperfectly analyſed by ſeveral chemiſts. From it's horny and fixed nature, we are told by Achard, that he was unable to extract any thing from it, by boiling it in water, in open veſſels; the hair he ſubmitted to experiment was that of the horſe, the goat, the dog, the calf, human air, and the wool of the ſheep.

After boiling each ſpecies of hair in Papin's digeſter, he found, that in one hour, it was become ſo ſoft as to give way when preſſed between the fingers, and to be ſomewhat ropy; that it had loſt very little of it's weight, but had depoſited in the water a gelatinous part, which gave it a yellow, or brown colour, and left by evaporation a glue; that the hair, except the human and wool, after being dried, had become brittle, and capable of being pulverized between the fingers, which, perhaps, aroſe from the loſs of it's gelatinous part.

Hatchett obſerved the ſame, for when hair of various qualities, and taken from different animals, was long digeſted, or boiled with diſtilled water, it imparted to the water a ſmall portion of gelatin, which was precipitated by the tanning principle, and by nitro-muriat of tin; and when the hair had been thus deprived of gelatin, and was ſubſequently dried in the air, the original flexibility and elaſticity of it were found to be much diminiſhed, ſo that it eaſily gave way, and was broken. And he is induced to believe from various experiments, that the hair which loſes it's curl in moiſt weather, and which is the ſofteſt and moſt flexible, is that which moſt readily yields gelatin ; on the contrary, the hair which is very ſtrong and elaſtic is that which affords it with the greateſt difficulty, and in the ſmalleſt proportion. Theſe remarks have been corroborated by the aſſertion of a conſiderable hair merchant in London, who, during a long experience of upwards of forty years, has always found, that hair of the firſt named quality cannot be boiled an equal time with thoſe laſt mentioned, without ſuffering material injury in ſtrength and flexibility.

By incineration, according to Achard, very little aſhes were left behind ; he found that one pound of each afforded the following quantity, viz :

	drachms.	grs.
Human	1,	20
goat's	1½,	⅔
pig's	1½,	22
ſheep's ..	1½,	2
calf's	2½,	10
dog's	2½,	22
horſe's	3,	12

The colour of the aſhes, in theſe experiments, was in general more or leſs yellow ; whilſt thoſe from the hair of the horſe were reddiſh. Thoſe from the human, horſe's hair, and dog's, were taſteleſs ; and from the goat's and pig's, only as he thinks accidentally ſaline. The water in which theſe aſhes had been lixiviated had no effect on the ſyrup of violets, which appears to prove, they contained no fixed alkali.

Neumann and Baſter, on the contrary, found a fixed ſalt in theſe aſhes.

Expoſed to diſtillation.

By diſtillation of theſe different ſpecies of hair, Achard obtained, beſides the carbonaceous reſiduum, empyreumatic oil, and the ammoniacal fluid, afforded by all animal ſubſtances, with a cryſtallized ſaline matter in the receiver, which was partly ſtellated, and partly rhomboidal. This, on the addition of potaſh, produced a very ſtrongly penetrating ſmell of ammonia, and a peculiar ſort of animal ammonia; which he thinks, might, perhaps, ariſe from the acid of benzoin, as in urine.

Quick lime.

Digeſted with quick lime, during it's extinction, wool and human hair loſt very little of their fixity, and nothing of their ſuppleneſs; on the contrary, that of the horſe, goat, and dog, as well as the briſtles of the pig, after undergoing this operation, and becoming dry, were very ſhort and brittle.

Alkalis.

Mild alkalis have no effect upon hair, either in the cold, or at a boiling heat; but by digeſting them twelve hours with cauſtic alkali, they were converted into a jelly.

According to Chaptal, if a cauſtic lye of potaſh be ſaturated with wool or hair, a ſoap is formed, which he calls the ſoap of wool.

Vitriolic acid.

Hair, put into the vitriolic acid for twelve hours, in which time it was coloured brown, had not loſt any of it's flexibility, but was ſofter; and the human hair, after it was waſhed and dried, appeared partly white. On digeſtion in this acid with heat, the hair was perfectly diſſolved, and produced a ſtrong ſmell of ſulphureous ſpirit. The ſolutions were not affected by dilution with water.

According to Berthollet, ſcoured wool put into ſulphuric acid was diſſolved by a ſlight heat; at firſt the ſolution was colourleſs, but on increaſing the heat, it ſoon became blackiſh. Diſtilled with ſulphuric acid, under a pneumatic apparatus, there came over a large quantity of gas, five ſixths of which were carbonic acid. This acid having been abſorbed, the reſiduum was hydrogen gas. At the end of the diſtillation, a conſiderable quantity of very white ſulphat of ammonia was ſublimed; there remained a coal in the retort.

Nitrous acid.

According to Achard, fuming nitrous acid, the fumes of which immediately changed dark and black hair to a reddiſh, and afterward to a white colour, without affecting it's ſolidity, corroded, and ſoon diſſolved both hair, wool, and briſtles. From this ſolution, pure water precipitated a yellowiſh flocky matter, half of which was ſoluble in alcohol, to which it gave it's yellow colour; and on the addition of water, became milky and turbid; which, however, became clear again after the depoſit of a flocky matter, greatly reſembling coagulated oil. This precipitate, on being diſtilled, afforded an alkaline water, a large quantity of empyreumatic oil, and a coal which left brick coloured aſhes. From the nitrous ſolution of the human hair, when evaporated to one half, aroſe ſome ſmall needle-like cryſtals. Weak nitrous acid had no effect on hair in the cold, but entirely diſſolved it at a boiling heat, became yellow, and had a ſweetiſh ſmell, the ſame as when boiled with fat oils, and other animal matters. Water, it appears, had no effect on this ſolution, which is ſomewhat extraordinary, ſince Berthollet having treated hair and wool with eight times the quantity of common nitrous acid in cloſe veſſels, obtained ſolutions, which, on becoming cool, depoſited a fat matter; and on cryſtallization, a large quantity of oxalic acid. This experiment of Berthollet lets great light on thoſe of Achard. From ſix drachms of wool, he obtained three drachms and four grains of the oxalic acid; hair alſo gave it a deal of fat, but not ſo much oxalic acid as wool.

Muriatic acid.

Achard found alſo, that the muriatic acid ſoftened hair in the cold, and entirely diſſolved it at a boiling heat. The dark brown, or nearly black ſolutions it forms, afford no depoſit on the addition of water.

Berthollet found, that the muriatic acid diſſolved wool more readily than the ſulphuric, but a more continued heat was neceſſary before the ſolution became black. Simply diſtilled with a receiver to the retort, a conſiderable portion of muriat of ammonia came over toward the end, one part of which was brown, whilſt that more advanced into the neck of the retort was white. There remained a much more conſiderable quantity of charcoal than with ſulphuric acid; the lixiviated coal gave a ſolution, which contained an evident quantity of iron. To judge of the vapours by the odour, which eſcaped toward the end of the operation, hydrogen gas was diſengaged. It may be remarked, that with the ſulphuric acid, very little coal remains, but much carbonic acid is obtained; whilſt with the muriatic acid, as a much greater quantity of carbon is left, we may conclude, that very little carbonic acid ought to be diſengaged.

Oxygenated muriatic acid.

According to the experiments of Van Mons, it appears, that the oxygenated muriatic acid gas converted quills, wool, calf's hair, and ſilk, after having been kept ſome days in it's atmoſphere, into gelatin; the two firſt ſubſtances acquired a red colour.

Alcohol.

Alcohol, vitriolic ether, the fat and ethereal oils have action upon hair either in the cold or with heat.

Light.

According to Thompſon, hair, as well as wool and ſilk, when expoſed under water to the rays of the ſun, emit dephlogiſticated air.

Fermentation.

From the dry and horny nature of theſe ſubſtances, they are prevented from undergoing the putrid fermentation; but we have an account given us by Carette, of the ſpontaneous combuſtion of wool. According to this author, wool and animal ſtuffs are liable to this change, when they are laid in heaps, accompanied with a certain degree of humidity. He gives an inſtance of an old woollen ball, which having been oiled in order to render it more elaſtic, and covered, ſome time after nothing but a black powder was found in the cover, which perfectly reſembled a carbon: he alſo relates, that a manufacturer of Liſle, having put a piece of cloth into his warehouſe which had not been cleanſed, it took fire in a few days after, and that ſeveral inſtances of the kind had occurred.

Spontaneous combuſtion.

This has been obſerved by Sonnini: he ſays, in the ſhipping of wool it is of importance to know, that great care ſhould be taken to prevent it's imbibing any moiſture, for in ſuch caſe, it heats, inflames, and is in danger of ſetting fire to the veſſel.

Component parts.

From theſe experiments it appears, that hair in a chemical view reſembles the fibrous parts, whilſt water only extracts a little of the gelatin. Wool inclines to a fatty nature, as the lye of cauſtic alkalis perfectly diſſolves it on boiling, and forms a ſoap with it as well as with hair.

It now remains to give a ſhort deſcription of the uſes of theſe ſubſtances in the arts, as far as they can be conſidered chemically.

The arts.

It is well known that the art of the hatter conſiſts in forming with hair, wool, and fur of different animals, a kind of ſtuff of a denſe, compact texture, capable of aſſuming and preſerving any figure that may be given it, To obtain this object, a variety of proceſſes are employed, partly chemical, and partly mechanical, which may be reduced to four principal operations, viz. felting, fulling, dyeing, and preparation.

FELTING.

If any ſpecies of hair or wool be inſpected by the microſcope, it appears ſmooth and poliſhed, yet if rubbed between the fingers, held by the point, and drawn to the root, the reſiſtance is more conſiderable than in the contrary direction; the motion is likewiſe tremulous, and there is a chirping noiſe. Likewiſe, if a hair be held between the finger and thumb, and rubbed by alternately moving them in the direction of it's length, a progreſſive motion will be produced, which is always with the root end foremoſt. The ſame ſtructure may be ſhown by tying two hairs together, and then giving the knot a few blows between the palms of the hands, for the knot will either untie itſelf or draw cloſer, according as the aſperities of the ſurfaces are placed in tying. From this mechaniſm which is common to wool, and every other kind of hair, which, according to Monge, have their ſurface compoſed either of ſcales like thoſe of fiſh or imbricated cones, like the horns of animals, may be deduced the harſh feel of woollens againſt the ſkin, compared with linens, and their irritating effect upon wounds. It is this diſpoſition to progreſſive motion end ways, which cauſes hair to entangle and *felt* itſelf when preſſed by the hatter between two pieces of linen, to which they do not unite from it's fibres being ſmooth. Cut hair is better than ſuch as is plucked, becauſe the bulbous roots prevent the progreſſive motion. The fibres of wool being crooked, muſt naturally move in curves; but thoſe of the hare, rabbit, and beaver, being ſtraight, cannot be uſed alone in felting, until after a previous operation, which conſiſts in rubbing them with a nitrous ſolution of mercury, by means of a bruſh, before they are ſeparated from the ſkin. The ſolution acting only on one ſide of the hairs, renders them crooked. The ſtraight hairs are uſed for felting hats, in which operation the action muſt be continued for a determinate time only, otherwiſe they would paſs through and come out on the oppoſite ſide. The diſpoſition of wool to felt itſelf, is an impediment to the carding and ſpinning proceſſes; hence oil is uſed, which diminiſhes the power of the hairs to act on each other; but at the fulling mill, ſoap and marle are uſed, which carry off the oil and reſtore the wool to it's former ſtate, in conſequence of which, the fulling proceſs takes place, and the cloths are rendered narrower, ſhorter, cloſer, ſtronger, and thicker. The balls of hair in the ſtomach of certain animals which lick each other, are felted by the action of the ſtomach. To which may be added, that a ſimilar cauſe is the chief reaſon why beds of cock and hen feathers are inferior to thoſe of gooſe feathers; the latter being much ſtraighter, do not form the hard flat balls which abound in the former. This work, which is entirely mechanical, forms the *felt*, which is a kind of ſoft ſpungy ſtuff, of greater or leſs thickneſs, and in it's firſt ſtate, of a looſe and imperfect texture. It's fibres would ſoon diſunite from their weak connection; hence to give it requiſite denſity and conſiſtence, it undergoes the operation of *fulling*.

Fulling. This, which is in a certain reſpect the completion of felting, has for it's object the intimate connection of the fibres, and a mere perfect and durable coheſion of the whole maſs. For this purpoſe, the mere mechanical act of preſſure is inſufficient; the reſult would be a formleſs maſs without conſiſtence. For the fulling, it is neceſſary to make uſe of a bath of water heated nearly to ebullition, into which are put, in France, ten or fifteen pounds of lees of wine, for every hundred pounds of water. The heat is kept up the whole time of working, and every three or four hours, a new quantity of lees is added. Into this bath the workmen plunge their *felt*, and begin their ſecond proceſs. The felt is dipped in, and immediately taken out again and ſqueezed, bent and rolled, by preſſure, in different directions, ſometimes with the hand defended by leather, and ſometimes by a roller, or other ſimilar inſtrument. This is repeated until the ſtuff is well condenſed, and has acquired the requiſite ſolidity; hence the lees added muſt be conſidered as a chemical ſolvent, acting directly on the ſubſtance of the hair, and producing, either by ſoftening or ſwelling it, an alteration neceſſary to inſure the coheſion of the different fibres of the ſtuff.

The editor of the French Encyclop. Méthod. affirms, that it is the alkali or potaſh of the lees, which determines the fulling. Chauſſier has, however, found the aſſertion of the editor to be erroneous; to prove which, nothing more is neceſſary than to dip a piece of blue paper in the bath, which inſtantly becomes red, and if after ſeveral hours work the ſtate of the bath be examined again, it is found that the acting part, which is the acidulous tartrite of potaſh, is partly exhauſted, and the workmen ſoon perceive the want of a new portion; and if we conſider the ſparing ſolubility of the acidulous tartrite in cold water, it will appear why the water muſt be kept nearly boiling. Hence it is evident, that it muſt act by the portion of acidule it contains. It was this firſt obſervation that induced Chauſſier to ſubſtitute the ſulphuric acid inſtead of the lees, which although unknown to this chemiſt, had been uſed as a great ſecret in foreign manufactures. He found twelve drachms of this acid ſufficient for one hundred pounds of water, and that this method was much preferable to that of wine lees, as being not only more convenient and economical, but the health of the workmen was not impaired by the exceſs and duration of the heat, the thick vapours, and the diſguſting odour which exhales from the bath, particularly when the lees had been putrid and mouldy. A boiling heat is not neceſſary as formerly; ninety, or one hundred degrees of Fahrenheit being ſufficient for good *fulling*. It alſo ſaves fuel; cauldrons of lead may be ſubſtituted for thoſe of copper, and the felt prepared is of ſuperior quality.

With reſpect to this proceſs, it is only neceſſary to mention, that hats felted in the new manner take the dye better than in the old way, and that oak bark is ſubſtituted to nut-gall with advantage.

Preparation. This proceſs, called *preparation*, conſiſts in lining the inner ſurface of the crown, as well as of the brim of the hat, with a glutinous ſubſtance, which, by drying, gives firmneſs to the work and preſerves it's form. This chemiſt found a ſolution of glue in a decoction loaded with the mucilage of linſeed oil the beſt, whilſt Margueron recommends the mucilage extracted from the leaves of the horſe cheſnut when it's foliage is in full vigour. A ſtrong decoction of theſe leaves, which contains a great portion of mucous and adheſive matter, is uſed with the glue. Theſe are better than gum arabic and other friable gums which become brittle.

Neumann's Chemical Works by Lewis, 2d. edit. vol. 2.—Withof, Anatom. Pili hum. Gotting. tom. 2.—Achard's Chem. Unterſuchung ueber die Beſtandtheile der Haare von verſchied. Thier. in his Chem. and Phyſ. Abhandlungen. 1. p. 166.—Berthollet, ſur la Nature des

Subſtances animales, Mém. de l'Acad. Royal des Sciences. 1784. Paris.—Leonhardi's Macquer's Wœrterbuch, vol. 7. article *Haare.*—Monge Annal. de Chim. vol. 6.—Chauſſier Obſervation ſur le Mecaniſme du Feutrage, Journ. Polytec. cap. 1, p. 160.

FEATHERS.

Feathers.

These, according to Hildebrandt, as well as other chemiſts, are ſimilar to hair. Hatchett found, that feathers, when digeſted in boiling diſtilled water during ten or twelve days, did not afford any trace of gelatin by the teſt of the tanning principle, but nitro-muriat of tin produced a faint white cloud. The ſame was obſerved when quill was thus examined.

SILK.

Silk.

This is the production of the larva or caterpillar of a phalena, of which ſeveral ſpecies afford it; the phalena atlas of Linnæus gives the greateſt quantity, but that from the phalena bombyx of Linnæus is the moſt generally made uſe of in Europe. The matter from which it is ſpun is found encloſed in two purſes or ſmall inteſtines of the animal, and this being taken out and extended, forms the Indian weed ſo well known to fiſhermen.

The native place of this inſect is China; whence it was carried to Hindoſtan and Perſia. Silk was not known in Greece or Rome till the reign of Auguſtus, and we are informed, that during ſeveral ages it was ſold for it's weight in gold. In 555, ſilkworms were tranſported from India to Conſtantinople, by two monks, and manufactures were made at Athens, Corinth, and Thebes, whence it was brought into Europe, in 1130, by Roger, king of Sicily, on his return from the Cruſade to the Holy Land; he eſtabliſhed manufactures at Palermo, and in Calabria; afterward it ſpread over Italy and Spain, and in the reign of James the Firſt was conveyed to England.

According to Reaumur, this is not the only animal that affords this ſort of matter; he found ſeveral ſpecies of ſpiders which encloſed their eggs in a very fine ſilk, and afforded a much finer and ſtronger thread than that of the common ſpecies; it was alſo of various colours, ſuch as white, yellow, ſky blue, gray, and coffee-coloured, but this has as yet undergone no chemical inveſtigation.

Silk is of different ſhades of colour; from a white, it goes through all the ſhades of yellow, even to a reddiſh colour. It is of a ſtiff texture, and ſhines from the gum varniſh that covers it.

Expoſed to the action of water.

Experiments of Chappe.

It is not acted upon by water at a boiling heat (it's gum is only affected); from what, however, Chappe has ſaid upon the ſubject, ſilk, before it is ſpun, and juſt taken from the caterpillar, may be ſo diluted with water as to form a ſort of gluten, which may be blown into bubbles offering all the colours of the rainbow, and far ſuperior to thoſe balloons made of ſoap and water, which ſoon vaniſh. On the contrary, we are informed that thoſe made of this ſilky matter are of a permanent texture, perfectly tranſparent, preventing even the moſt light gas from penetrating through it. He has formed ſmall balloons of it, the diameter of which did not exceed three inches, which he filled with hydrogen gas, and kept ſuſpended in an apartment, nor had many of them ſuffered any thing after twenty-four hours. To form this gluten, great care is required; it cannot have all it's ſuppleneſs and ductility until it has arrived at it's greateſt maturity, which is when the worm is diſpoſed to form it's ſilk. That the yellowneſs of which is too marked, a diſeaſed ſtate very common to theſe inſects, will not do. After being cut from the worm, it muſt be put into a glaſs, unbruiſed, and when a ſufficient quantity is procured, it muſt be well waſhed and cleaned with great precaution; the water decanted and freſh applied. By the effect of the ſolution of the colouring parts of the ſilk, as well as of the excrementitious parts of the inſect, this chemiſt informs us, this pure and tranſparent water becomes turbid, yellowiſh, and obſcure, and in an hour, of a green, tending to a black. In this ſtate it muſt be decanted and freſh water added, and repeated until the yellow is extremely weakened, and the obſcure green diſſipated. The thermometer of Reaum. being at 12 or 15° above zero, two hours and a half are ſufficient to diſſolve the colouring parts and excrements, of which it muſt be purged to poſſeſs all it's ductility. The matter thus prepared is to be put into a glaſs mortar, a little diſtilled water added, and the mixture to be accelerated by trituration; a little more water is then added as the liquor thickens, whilſt one part of water to three of the ſilky matter, commonly gives it all the ſuppleneſs and ductility neceſſary. In about half an hour after, it's weak yellow colour becomes of a greeniſh tinge, which is the time of it's being ready.

Chappe took tubes of glaſs, of a line or more at the orifice, and ſomewhat excavated at the inferior part, which he uſed in the ſame manner as in making balloons of ſoap and water; it muſt be ſo blown as to be made at ſeveral times, for a rapid and ſudden diſtention always deſtroys it. When it has acquired it's utmoſt extenſion, which, in general, does not exceed three inches, the water is let evaporate without detaching the bubble from the tube; it is then dried in the ſun. To take away the internal drops of water, Chappe uſed a ſmall capillary conical glaſs tube, by which he attracted them. The colours ariſe in proportion as the water evaporates, and preſent themſelves in the ſame order as thoſe of the rainbow. Expoſed to the air, it becomes tarniſhed and opake, but by means of a glaſs and vapour, may be preſerved for ſeveral years. It has been uſed in medallions, and as ornaments for buttons.

Nitrous acid.

Berthollet found, that the nitrous acid perfectly diſſolved ſilk. By means of ſeven or eight parts of the firſt, to one of the other, he obtained ſome oxalic acid, but not ſo much as from wool; and a fatty matter was depoſited.

Nitrous acid.

Welter, having treated ſome ſilk with the nitric acid in order to extract ſome oxalic acid, he was ſurpriſed at the end of the operation not to find any, but inſtead of it, he found an unknown ſalt, ſilky, of a gold colour, and which, on the approach of a red hot coal, took fire like gunpowder.

The manner in which he made the experiment was this. On one part of ſilk, he poured ſix parts of common impure nitric acid, to which he added a little concentrated nitric acid. The mixture was left to repoſe two days, and then diſtilled. He then returned what had come over into the retort again, and put it on a filter. As he thought the oxalic acid cryſtallized too quickly, he poured it back into the retort again, and added to it ſome water which had ſerved to waſh the filter. He then extracted a part of the water, and endeavoured to cryſtallize the reſiduum, which did not take place; he then added what was in the receiver to that in the retort, and diſtilled it again. At laſt, having performed the ſame circle of operations for ſeveral times, the reſiduum was an acid liquor, containing ſome ſmall granular cryſtals, (which were not examined) and it was reduced to about one half of the ſilk employed.

This liquor ſubmitted to different proofs ſhowed no trace of oxalic acid; it was yellow, tinged the fingers of that colour, and communicated to white ſilk a beautiful yellow, which was not weakened by waſhing it with water. To ſaturate this liquor he mixed ſome chalk with it, and finiſhed the ſaturation by lime; having afterward extracted it, he poured ſome alcohol upon it, and there ſeparated a gummy matter to all appearance, which was ſet apart. The alcohol was diluted with water and evaporated. There remained a yellow ſubſtance with the ſolutions of muriat and nitrat of lime. Having decompoſed theſe ſalts by the carbonat of potaſh, and ſeparated the carbonat of lime, the decanted liquor was left on a ſand bath. The day after, the glaſs was found lined with gold coloured cryſtals equal to ſilk in fineneſs, which detonated like gunpowder; the ſmoke reſembled that from burnt reſin.

It's properties.

This yellow ſalt is ſoluble in water and alcohol. It cryſtallized on cooling. Oxygenated muriatic acid poured upon it's ſolution, deprives it of it's yellow colour, and renders it milky.

The ſulphuric acid diſengages the odour of nitrous acid from it's cryſtals. The muriatic acid precipitates from it's ſolution ſome ſmall, whitiſh, micaceous cryſtals, which in the fire are volatilized into a ſmoke bitter to the palate. This ſmoke is inflammable, and burns like eſſential oils.

He treated ſome freſh ſilk by the nitric acid, and, after having obtained at different times cryſtals of oxalic acid, he poured ſome weak nitric acid on the reſiduum, which was of the conſiſtence of honey. After having warmed the mixture to diſſolve all of it, it was left to repoſe two days, when he again found ſome cryſtals of oxalic acid, and ſome granulated, yellowiſh cryſtals, extremely bitter and without any acidity, tingeing the ſaliva and the tongue of a yellow colour, volatile in the fire, and indeſtructible by the concentrated nitric acid, which only took away their colour, and this on dilution with water reappeared.

Having ſaturated a little nitric acid, mixed with this ſubſtance, with potaſh, it was evaporated, and the reſiduum took fire like the ſilky ſalt before mentioned. Welter looks upon this laſt to be a triple ſalt, compoſed of nitre of potaſh combined with the yellow ſubſtance to which he has given the name *Bitter*.

called, *Bitte.*

The cryſtals of yellow *bitter*, examined by the magnifier, appeared to be octoedrical, having two oppoſite ſummits truncated, whence reſult ſquare rectangular tablets, the edges of which are cut ſloping towards the two ſurfaces.

Since animal ſubſtances become yellow by the contact of the nitric acid, Welter endeavoured to extract *bitter* from the fleſh of the ox; but he found it combined with another ſubſtance, which was as unalterable as itſelf by the nitric acid. This combination, ſoluble in concentrated nitric acid, is ſeparated from it by water, in the form of a yellow powder, which does not loſe it's colour in the air, and which may perhaps be of uſe in the art of painting.

What gave Welter reaſon to preſume that the yellow powder was compoſed of *bitter* and of another new ſubſtance was, that, on treating ſpunge by the nitric acid, he obtained ſome of this laſt ſubſtance, without colour, ſoluble in concentrated nitric acid like the preceding powder, and, like it, capable of being precipitated by water; knowing, beſides, how greedy *bitter* is of combination, eſpecially with animal matters, and how ſolid it's tinctures are.

Welter thinks that bile, perhaps, owes it's colour and bitterneſs to this ſubſtance, which he calls *bitter*.

Muriatic acid.

The vitriolic as well as the muriatic acids, when concentrated, diſſolve ſilk.

Dephlog. mur. a.

According to Weſtrumb, ſilk and wool, when treated with the dephlogiſticated muriatic acid gas, or when diluted with water, inſtead of being bleached like cotton and linens, always became of a yellow colour, and loſt a part of their ſolidity.

Alkalis. The cauſtic alkalis corrode and diſſolve it.

Fire. Silk, on being expoſed to heat, gives by diſtillation the ſame as other animal ſubſtances. According to Neumann, few ſubſtances afforded him ſo much volatile alcali; and Tournefort ſays, that it contains more than hartſhorn; from 15 ounces of ſilk he obtained 2 drachms of volatile ſalt.

Hence it appears, that ſilk, like coal, reſembles the fibrous matter, although it has been looked upon as concrete albumen. Fourcroy looks upon it as a kind of vegetable mucilage or gummy matter, with a peculiar animal oil, which gives it flexibility, ductility, and elaſticity. It, however, differs from vegetable ſubſtances; firſt, by the volatile alkali it affords by diſtillation; ſecondly, by the carbonic acid gas obtained from it by the nitrous acid; and thirdly, by the peculiar oil which this acid ſeparates, in proportion as it converts it into ſaccharine acid. According to Gren, it is an animal-vegetable matter, the vegetable part proceeding from the food of the worm. It is convertible into paper. Light. Gadolin found that crude ſilk expoſed to the ſun, after being moiſtened, afforded a great deal of dephlogiſticated air.

Varniſh of ſilk. Silk is divided into two kinds, viz. *unwrought* or *crude*, and *wrought*. In it's natural ſtate it is diſtinguiſhed by the firſt name, being covered with a varniſh, which by ſome has been looked upon as a gum, by others as a reſin, to which it owes it's ſtiffneſs, brilliancy, and elaſticity. Bergman, on the contrary, affirmed, that this varniſh was neither gum nor reſin, but of an oily nature. Deprived of this it is called *wrought ſilk*. It likewiſe contains a yellow colouring part.

This varniſh is ſoluble in boiling water, and conſtitutes ſomewhat more than one quarter of the weight of the ſilk.

According to Berthollet, when ſeparated it is black, brittle, and of a ſhining fracture.

Hot water.

It is eaſily ſoluble in hot water, and Berthollet found, that it left very little reſiduum on the filter; the ſolution, which was clear and of a greeniſh yellow colour, was not ſenſibly affected, either by acids or by alkalis. A ſolution of alum produced a precipitate of a dirty white, that of ſulphat of copper of a dark brown, and that of ſulphat of iron of a brown colour. A ſolution of muriat of tin gave a white precipitate, and acetite of lead a brown one. All theſe precipitates were in ſmall quantity, and more or leſs viſcous. An infuſion of galls or of ſumach produces a white precipitate. Alcohol does not diſſolve this ſubſtance even by ebullition; it, however, takes up it's yellow colouring part.

Alcohol.

Diſtillation.

On diſtillation, Beaume and Berthollet obtained the ſame products as from animal ſubſtances. Hence this varniſh is of an animal nature, which is the reaſon that ſoapſuds, which have been made uſe of to deprive the ſilk of it, eaſily become putrid. When it is no longer retained by the affinity it has for the ſilk, it is eaſily, as has been ſeen, ſoluble in water, but not in alcohol. Berthollet is of opinion, that, although this ſubſtance is not of a vegetable nature, the name of gum is well adapted to it.

It's colouring part ſoluble in alcohol.

The yellow colouring part which ſilk poſſeſſes beſides it's gum, and which has been juſt obſerved to be ſoluble in alcohol, being ſeparated by this means, the gum is brown, which ariſes from the heat it ſuffers from ebullition; for if this colouring part be taken off by the proceſs of Beaume, which will be deſcribed, the ſilk remains white. This alcoholic ſolution of colouring matter left, on evaporation, a ſcaly reſiduum of an amber yellow colour.

Berthollet mixed a few drops of muriatic acid with nearly two ounces of alcohol, which he boiled on 20 grains of ſilk gum, when a ſolution took place; but, on cooling, it took the form of a jelly.

Bleaching. For the greater part of uſes in the arts to which ſilk is deſtined, it is neceſſary that it ſhould be deprived both of it's gum and colouring part. This double object, according to Berthollet, is effected by means of ſoap; and to make the operation more or leſs perfect depends on the proportion of the ſoap, although it appears to change the luſtre of the ſilk. Thus, for inſtance, to make it fit to receive ordinary colours, a ſolution of 20lbs. of ſoap to 100lbs of ſilk is ſufficient, taking care to have a ſufficient quantity of water, and the boiling to continue three or four hours. For ſilk that is to be died blue, the quantity of ſoap is augmented, and a larger quantity is employed for ſcarlet, cherry colours, &c., ſince it is neceſſary for theſe colours, that the ground of the ſilk ſhould be whiter than for leſs delicate colours. If the ſilk is to be uſed white, it undergoes three operations with ſoap, and in the laſt it is called the *bleaching*, by which a light ſhade is given it under different names, as China white, ſilver white, azure white, thread white, &c.

For the China white a ſlight reddiſh tinge is communicated to it by an American ſeed (bixa orellata, Lin.) called anotta. For the azure, a little refined indigo is uſed. After this it is neceſſary to expoſe it to the vapour of ſulphur, if intended for white ſtuffs, ſince the whiteneſs from the preceding proceſſes is not ſufficiently ſplendid.

The Abbe Columb found that ſilk, ſcoured by the action of water alone at a boiling heat, became much better for dyeing, and was more ſtrong than that ſcoured by ſoap. A ſtrong ebullition of eight hours, however, is neceſſary to diſſolve all the varniſh of the ſilk, but it preſerves it's yellow colour.

For a far ſuperiour proceſs we are indebted to Beaume, who arrived at depriving yellow ſilk of it's colouring part, without attacking it's gum, and, conſequently, without depriving it of it's elaſticity and brilliancy. Before the labours of this chemiſt, the art of bleaching ſilk was unknown in Europe; and he informs us, it coſt him ſix years of great diligence and induſtry to create and bring it to perfection. The only author who had written on this ſubject was Poivre, who believed, that in China the ſilk was bleached by expoſure to the ſun, and he looked upon this luminary as the only bleacher of ſilk.

The Nankin ſilk is perfectly white, ſilvery, brilliant, and, not being deprived of it's gum, has all the ſtiffneſs natural to unboiled ſilk; and the great deſideratum was to give that of Europe the ſame whiteneſs, without depriving it of the other properties. It was believed, that the Nankin ſilk was natural; and the late Soudaine obtained ſome eggs from China, from which he got ſilk both of a yellow colour and ſome as white as the Nankin. It appears, however, that almoſt all from that country is bleached by a proceſs, which Beaume informs us he has diſcovered.

Extinction of the cods.

His firſt object was the deſtruction of the cryſalis, which pierces the ſilky cod in ten or twelve days. This had been effected by a furnace, heated to 70°. But the inconveniences were, that the heat ſpoils a part of the ſilk on the ſurface of each cod, hardens it, and makes it difficult to ſoften in warm water at the time of winding. One pound of ſpun ſilk is commonly procured from 8lbs. of the cods, whilſt 18 ounces of the ſame, but more beautiful and brilliant, are procured from the ſame quantity of green cods, or thoſe which had not been expoſed to the furnace, and the winding is performed by a leſs heat and with more eaſe. Hence the uſe of a method of winding the ſilk, when green, without the inconveniences of the fire; in which Beaume ſucceeded by means of alcohol, with this advantage, that this method ſhows the cods, in which the cryſalis was previouſly dead, and which muſt be ſeparated from the others, ſince the inſect ſoon becoming putrid, furniſhes a liquor, which gives the ſilk a deep brown colour; and theſe are diſtinguiſhed by having brown or black ſpots on their ſurface.

1ſt Infuſion. Previous to the bleaching, the wound ſilk muſt be infuſed in water at about 45° for two hours, to deprive it of a little of it's gummy part. During this infuſion, it ſoftens, and the water is rendered ſlightly amber-coloured; the ſilk is then dried, and being thus prepared, 6lbs. of it are put into a well waſhed ſtone pot, to which are added 48lbs of alcohol mixed with 12 ounces of very pure muriatic acid; the pot is then covered, left until the next day, or until the liquor from it's beautiful green paſſes to the colour of dead leaf; the liquor is then let run out by a hole in the bottom, and alcohol is poured upon the ſilk at ſeveral times, and let run off, until it runs off clear.

2d Infuſion. The ſilk now undergoes a ſecond infuſion of the ſame kind as the firſt; it is then left covered twenty-four hours, or ſometimes two, three, and even ſix days, until the ſilk becomes perfectly white, and is afterwards waſhed by pouring alcohol upon it until it runs off clear.

3d Infuſion. It is now ſubmitted to a third infuſion of alcohol alone, 48lbs. of which are poured upon it; it is let ſtand until the next day, and the alcohol is then laid aſide to waſh the ſilk of the firſt infuſion. When nothing more runs from it, it ſtill retains it's weight of alcohol, which is to be waſhed away by clear river water, until nothing but water runs off. The marine acid likewiſe, with which it is impregnated, is to be waſhed off by the ſame means; but the water muſt contain no nitre, as this tarniſhes it. The ſilk is placed under the pump, and coarſe cloth put over it for a filter, the water is then made to paſs through the ſilk, until it no longer reddens the tincture of litmus; the pot is then ſtopped and filled with water, which is changed once or twice every twenty-four hours, after which the ſilk is completely bleached and waſhed. If the muriatic acid be not completely waſhed off, the ſilk is rough to the touch, and in time it's threads become brittle. If it be wrapped in woollen, and placed in the current of a river, it is completely waſhed in five or ſix hours.

Remarks.

It appears that, although the mineral acids are of all ſaline ſubſtances the moſt active and deſtructive, they may, however, be applied to ſilk by the intermedium of alcohol without detriment. Beaume has even uſed two ounces of muriatic acid to 1lb. of alcohol without any hurt to the ſilk, and this acid is preferable to the two others, provided it be free from the nitrous acid, as this laſt has the inconvenience of reddening the ſilk; but alcohol mixed with muriatic acid extracts from yellow ſilk a colour, which immediately paſſes to a beautiful green tending to a blue. This on three or four hours expoſure to the ſun becomes of the colour of dead leaf, whilſt pure alcohol alone extracts a beautiful lemon colour from the yellow ſilk, which is not affected by the ſun, and is not depoſited for ſeveral years, although the ſame ſilk, encloſed in a bottle and expoſed, loſes it's colour in a ſhort time.

Alcohol alone poſſeſſing the property of taking away the yellow colour of the ſilk, it was the intention of Beaume to have employed it; but, although it has the advantage of converting theſe yellow ſilks into a ſtate of natural whiteneſs, and they are afterwards made perfectly white by one infuſion only of the alcohol and the acid, yet it is not ſufficient to bleach them entirely, and it has likewiſe inconveniences which the other has not.

To this may be added, that, in order for the firſt infuſion to have been well made, the ſilk muſt have loſt all it's yellow colour, and the liquor have changed it's colour a little; that it's duration depends on it's temperature; at 20°, it is often made in ten or twelve hours; if expoſed to the baln. maræ in two or three hours, and all the infuſions may be made in one day. After this firſt infuſion, the ſilk appears of a greeniſh colour, which goes off on waſhing.

By theſe means the yellow ſilks of Europe may be obtained as beautiful, and even more ſo, than thoſe of Nankin, and by bleaching the white ſilk, which is natural, it is infinitely more beautiful.

ATTRACTION OF THE EXTERNAL PARTS FOR COLOURING MATTER.

Attraction of the external parts for colouring matter.

SINCE the exteriour parts of animals are converted into artificial clothing, and are ſubject to have their natural colours changed for a variety of others by the art of dyeing, it will be neceſſary, before the concluſion of this article, to take ſome notice of the chemical attraction they have for colouring matter.

It appears that, from the different compoſition of animal ſubſtances when compared with vegetable, the azote and hydrogen of the firſt being diſpoſed to take an elaſtic ſtate, their component particles have leſs adherence to each other than thoſe of the ſecond; hence hair, wool, and ſilk have a ſtronger attraction for colouring matters than cotton, linen, or hemp. With reſpect to wool, the laminæ or zones, which form the roughneſs of it's fibres, are well fitted to contain the particles of colouring matters; but their interſtices being ſmall, no colour, according to Bancroft, can be conveyed into the cavities, until dilated by hot or boiling water, which is not the caſe with ſilk. This dilation and contraction of the interſtices, with the ſuperiour chemical attraction, which animal fibres have for colouring matters, explain why many colours, dyed upon wool and hair, proved ſo much more durable than on cotton and linen, and the finer and whiter the wool, the ſooner and more penetrated it is with the matter, whilſt the coarſe wool receives colours with difficulty; likewiſe from it's ſtrong attraction, wool is died ſcarlet in a bath, which has no effect on cotton. With reſpect to ſilk, from it's leſs diſpoſition to receive and retain colours, or to combine with colouring matter, it bears ſome reſemblance to vegetable ſubſtances, or rather ſeems to partake of a middle nature between the animal and vegetable, which may ariſe from it's fibres having neither a ſimilar organization, by which it is capable, like wool, of having it's pores opened by hot water, of which it has no occaſion, like the vegetable, or, more probably, as Berthollet is of opinion, from it's containing leſs azote and hydrogen; colours however dyed on ſilk are more laſting than when dyed on linens and cottons, which is the reſult of it's greater affinity with the colouring matter.

Mordants in dyeing.

Another circumſtance reſpecting theſe ſubſtances is, that from their difference of compoſition they are more likely to be deſtroyed by mordants*, by their greater affinity for them than vegetables have; hence, fixed alkalis, pure or cauſtic, deſtroy them by their combination to ſaturation, and by this means loſe their cauſticity. Hence it follows, that wool, hair, and ſilk are not able to ſuſtain the lyes, and the employment of alkalis can only be made

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N. B. Mordants are thoſe ſubſtances that ſerve as a medium of union between the colouring matter and the ſubſtance to be dyed.

with great precaution in the proceſſes of dyeing them, which is unneceſſary with reſpect to cotton, linen, &c. Wool, as it is naturally clothed with a fatty ſubſtance, undergoes the act of ſcouring previous to taking the dye. This is generally done by hot water and putrid urine, which, when the wool no longer is milky, is ſufficiently cleanſed. In this proceſs the ammonia combines with the fatty ſubſtance, and forms a ſoap, which renders it ſoluble in water. For the generality of colours it is prepared by being boiled with ſaline ſubſtances, as alum, and tartar, called the *boiling*. Silk, from the ſame reaſon, as it has leſs affinity with colouring matter than wool, affords a greater reſiſtance to the action of mordants; but although their action is weaker than on wool, it is neceſſary to make uſe of them with great precaution, ſince the brightneſs of colour, required in ſilk, appears to depend on the moothneſs of it's ſurface.

The mordant for ſilk is alum; without this, the greater part of the colours applied to it would have neither beauty nor durability; when, therefore, the ſilk has been ſoap-waſhed, it is put into a cold alum bath for about eight hours, and then waſhed; a hot bath would impair the luſtre of the ſilk.

It therefore appears that alumine is the grand mordant for animal ſubſtances, and the affinity which it has for them has been proved by Berthollet by direct experiment. He formed this combination by mixing an alkali ſaturated by an animal ſubſtance, with a ſolution of alum. A double exchange was the conſequence. The alkali united with the acid of the alum, whilſt the alumine combined with the animal ſubſtance was precipitated. He likewiſe proved it by another experiment. Having mixed a ſolution of glue with a ſolution of alum, he precipitated the alumine by an alkali, which was found to have dragged the glue along with it, and to have united with it. It had the appearance of a ſemitranſparent jelly, and dried with difficulty. The reaſon of tartar being added to the alum, with reſpect to the wool, is, that as it is much more tender than ſilk, it moderates the too lively action of the alum upon it. All metallic oxyds, likewiſe, ſerve as mordants to animal ſubſtances, and even ſome animal ſubſtances themſelves.

Neumann's Chemiſtry by Lewis, vol. 2.—Fourcroy's Elements.—Découverte d'un Tiſſu tranſparent de la Matière ſoyeuſe du Ver à Soie, par M. Chappe. An. de Ch. tom. 2. p. 113.—Notice ſur quelques Matières particulières, trouvées dans les Subſtances animales, traitées par l'Acide nitrique, par le Cit. Welter, ibid. No. 87. p. 301.—Sur le Combuſtion de différens Corps dans l'Acide muriatique dephlogiſt. par M. Westrumb. ibid. tom. 6. p. 240.—Obſervations ſur la Diſſolution du Vernis de la Soie, par M. Coulomb. Journ. de Phyſ. Juill. 1785. p. 95.—Berthollet, Elémens de l'Art de la Teinture. 2 vol. Paris. —Bancroft on Permanent Colours. London, 1794.—Mémoire ſur le Blanchiment des Soies ſans les décruer ſemblables à celles connues ſous le Nom de Sina et de Soies de Nankin par M. Beaumé. Journ. de Phy. tom. 1. p. 375. 1793.

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